Proceedings of the Thirtyfirst Indian Science Congress

Delhi, 1944.

PART I

CONTENTS

Proceedings of the Thirtyfirst Indian Science Congress

CHANGE OF VENUE

The University of Travancore invited the 31st Session of the Science Congress at Trivandrum. The Reception Committee formed under the auspices of the University was completing all necessary arrangements when they received information about severe restrictions in railway transport. Owing to the peculiar geographical location of the city it was feared that many members would find it extremely difficult to reach Trivandrum. At the same time, the Reception Committee was anxious that the members intending to attend the Session should have fullest facilities for doing so. They therefore sought the advice of the Executive Committee of the Association towards the beginning of October. The Executive Committee considered the situation carefully in the light of the facts placed before them and agreed with the Travancore University that an attempt should be made to hold the Session, if possible, elsewhere. The University of Delhi having kindly extended the invitation, the 31st Session of the Science Congress was held at Delhi.

The following appointments at Trivandrum were made. On account of the change of venue of the Congress all officers appointed at Trivandrum resigned their offices. The full list of officers of the Thirtyfirst Congress is given under the proper heading.

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Sachivottama Sir C. P. Ramaswamy Aiyar, K.C.S.I., K.C.I.E., LL.D., Dewan of Travancore and Vice-Chancellor of the University of Travancore.

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Physics.—Prof. V. Sivaramakrishna Iyer, M.A., Professor of Physics, University College, Trivandrum.

Chemistry.—Prof. K. R. Krishna Iyer, M.A., Professor of Chemistry, University College, Trivandrum.

Geology and Geography.—V. Mahadevan, Esq., M.A., State Geologist, Government of Travancore, Trivandrum.

Botany.—Prof. T. K. Koshy, M.A., Ph.D. (Lond.), F.L.S., Professor of Botany, University College, Trivandrum.

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29—39. **(f) Sectional Presidents for the Session (vide list above). Ex-officio.**

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Mr. M. R. Mahajan	*Recorder.*
Prof. G. Sankaran	*Sectional Correspondent.*
Dr. H. L. Khosla	*Local Sectional Secretary.*
Dr. H. N. Ray	*Elected Members.*
Mr. A. K. Sen	
Lt.-Col. S. S. Sokhey	*Past Presidents who are either Ordinary or Honorary Members.*
Lt.-Col. K. R. K. Iyengar	
Sir R. N. Chopra	
Sir U. N. Brahmachari	
*Rao Bahadur T. S. Tirumurti	
Mr. J. R. Haddow	
*Mr. A. C. Ukil	
*Dr. C. G. Pandit	
Dr. F. C. Minett	
Dr. M. B. Soparkar	*Past Recorders who are either Ordinary or Honorary Members.*
Prof. S. W. Hardikar	
Capt. S. Datta	
Dr. Phanindranath Brahmachari ...	
Dr. G. D. Bhalerao	

9. Agricultural Sciences—

Rao Bahadur D. V. Bal	*Convener.*
*Dr. S. V. Desai	*Recorder.*
Dr. R. P. Mitra	*Sectional Correspondent.*
Dr. B. Viswanath	*Local Sectional Secretary.*
Dr. S. P. Raychaudhuri	*Elected Members.*
Dr. K. C. Sen	
Rao Bahadur M. R. Ramaswami Sivan ...	*Past Presidents who are either Ordinary or Honorary Members.*
Sir T. S. Venkatraman	
Sir T. Vijayaraghavacharya	
Rao Bahadur G. N. Rangaswami Ayyangar	
Khan Bahadur Mian Afzal Husain ...	
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Rao Sahib T. V. Ramakrishna Ayyar ...	
Rai Bahadur Jai Chand Luthra	
Mr. K. Ramiah	
Dr. Nazir Ahmad	
Rao Bahadur Y. Ramchandra Rao ...	
Mr. N. V. Joshi	*Past Recorders who are either Ordinary or Honorary Members.*
Dr. A. N. Puri	
Dr. C. N. Acharya	
Mr. N. L. Dutt	
Dr. J. K. Basu	

10. Physiology—

*Prof. S. N. Mathur	*Convener.*
Prof. S. A. Rahman	*Recorder.*
Mr. S. Banerjee	*Sectional Correspondent.*
Dr. N. K. Basu	*Local Sectional Secretary.*
Dr. P. N. Brahmachari ... ... Dr. S. N. Ray	*Elected Members.*
Lt.-Col. S. L. Bhatia ... ... Dr. W. Burridge ... ... Sir R. N. Chopra ... ... *Prof. N. M. Basu ... . Dr. W. R. Aykroyd ... ... *Dr. B. B. Dikshit ... ... Rao Bahadur B. T. Krishnan ... ... *Prof. B. Narayana	*Past Presidents who are either Ordinary or Honorary Members.*
Dr. B. Mukerji ... . Mr. K. Mitra ... . Mr. B. Chatterji	*Past Recorders who are either Ordinary or Honorary Members.*

11. Psychology and Educational Science—

Mr. John Sargent	*Convener.*
Mr. S. Sinha	*Recorder.*
Mr. S. Roy	*Sectional Correspondent.*
Mr. Samuel Mathai	*Local Sectional Secretary.*
Mr. A. N. Basu ... ... Dr. N. Mukerji	*Elected Members.*
Dr. N. N. Sen-Gupta ... ... *Mr. N. S. N. Sastry ... ... Prof. G. Bose ... ... *Mr. M. N. Banerji ... ... Dr. S. C. Mitra ... ... Mr. J. M. Sen ... ... Mr. K. C. Mukherji ... ... Mr. Haripada Maiti ... ... *Dr. I. Latif ... ... *Dr. Gopeswar Pal ... ... *Prof. B. L. Atreya	*Past Presidents who are either Ordinary or Honorary Members.*
Mr. D. Ganguly ... ... Mr. S. K. Bose	*Past Recorders who are either Ordinary or Honorary Members.*

12. Engineering and Metallurgy—

Mr. J. J. Ghandy	*Convener.*
Prof. H. L. Roy	*Recorder.*
Prof. M. Sen-Gupta	*Sectional Correspondent.*
Mr. R. N. Mathur	*Local Sectional Secretary.*
Dr. P. C. Mahanti ... . Prof. S. R. Sen-Gupta	*Elected Members.*
Mr. C. C. Inglis ... ... *Dr. A. H. Pandya ... ... *Mr. N. V. Modak	*Past Presidents who are either Honorary or Ordinary Members.*

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Mr. D. N. Wadia (Colombo)
Pandit Jawaharlal Nehru (Allahabad)
Dr. J. B. Grant (Calcutta)
Prof. S. K. Mitra (Calcutta)
Prof. P. Parija (Cuttack)
Prof. M. N. Saha (Calcutta)
Prof. B. C. Guha (Calcutta)
Dr. S. C. Mitra (Calcutta)
Prof. D. D. Kanga (Madras)
Dr. Gilbert J. Fowler (Bangalore)
Dr. C. N. Acharya (Bangalore)
Dr. Kewal Motwani (Bombay)
Mr. A. N. Basu (Calcutta)
Mr. A. C. Ukil (Calcutta)
Prof. Benoy Kumar Sarkar (Calcutta)

4. LOCAL RECEPTION COMMITTEE

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Sir Maurice Gwyer, K.C.B., K.C.S.I., D.C.L., LL.D., Vice-Chancellor, University of Delhi.

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Lt.-General Sir Clarence Bird, Master-General of the Ordnance in India, New Delhi.
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Rao Bahadur Dr. B. Viswanath, Director, Imperial Agricultural Research Institute, New Delhi.
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W. W. Wood, Esq., Principal, Delhi Polytechnic, Delhi.
Dr. Zakir Husain, Jamia Nagar, Okhla, Delhi.
Lala Jagan Nath, Rais, Subzi Mandi, Delhi.
Lala Ram Roop, Rais, Subzi Mandi, Delhi.
Lala Om Prakash, Rais, Saddar Bazar, Delhi.

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Rai Sahib Ratan Lal, 75, Daryaganj, Delhi.
Rai Bahadur N. K. Sen, Registrar, University of Delhi.
Dr. S. N. Sen, Keeper of Imperial Records, Govt. of India, and Professor of History, University of Delhi.
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Dr. R. S. Thakur, D.Sc., Asst. Secretary, Supply Development Committee, New Delhi.

LOCAL SECRETARIES

Sir S. S. Bhatnagar, F.R.S., Director of Scientific and Industrial Research, Delhi, and Professor of Chemistry, University of Delhi.
Prof. D. S. Kothari, Professor of Physics, University of Delhi.

ASSISTANT LOCAL SECRETARIES

Dr. B. D. Laroia, Officer-in-charge, Central Drugs Laboratory, Delhi.
Dr. B. L. Manjunath, D.Phil (Oxon.), Chief Editor, Dictionary of Raw materials and Economic Products, 20, Pusa Road, Karol Bagh, New Delhi.
Dr. Ram Behari, Ph.D., Reader in Mathematics, Delhi University, St. Stephen's College, Delhi.
Dr. B. R. Seth, D.Sc., Professor of Mathematics, Hindu College, Delhi.
Dr. S. Siddiqui, Asst. Director of Research, B.S.I.R., Delhi.
Dr. Lal C. Verman, Asst. Director of Research, B.S.I.R., Delhi.

TREASURER

Rai Bahadur S. N. Mukarji, M.A., Principal, St. Stephen's College, Delhi.

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5. FINANCIAL ARRANGEMENTS FOR THE THIRTYFIRST SESSION

The Local Reception Committee made all local arrangements necessary for the transaction of the scientific work of the meeting and for accommodation of the members and the delegates, who attended the session.

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6. LIST OF DELEGATES

A. DELEGATES FROM OUTSIDE INDIA

American Association for the Advancement of Science.

Prof. M. O. P. Iyengar.

Faculty of Medicine, Kabul.

1. Prof. S. A. Akhtar.
2. Prof. Zohdi Burke.
3. Prof. Farook Ilhan.

B. DELEGATES FROM UNIVERSITIES, LEARNED SOCIETIES, RESEARCH INSTITUTES, COLLEGES, STATES AND GOVERNMENT DEPARTMENTS

Annamalai University.
1. Dr. K. I. Kuriyan.

University of Bombay.
1. Prof. G. R. Paranjpe.
2. Prof. K. Venkataraman.

University of Dacca.
1. Prof. N. M. Basu.
2. Mr. Jyotirmay Bhattacharyya.
3. Mr. Chittaranjan Bose.
4. Prof. S. N. Bose.
5. Prof. J. K. Chowdhury.
6. Mr. Quazi Motaher Hossain.
7. Dr. S. R. Khastgir.
8. Dr. P. Maheswari.
9. Mr. K. C. Mukherjee.
10. Dr. S. P. Raychaudhuri.
11. Dr. A. T. Sen.

University of Madras.
1. Mr. R. Gopala Aiyar.
2. Mr. M. Damodaran.
3. Mr. George Kuriyan.

Nagpur University.
Rao Bahadur Dr. D. V. Bal.

University of the Panjab.
1. Dr. Bashir Ahmad.
2. Dr. P. L. Anand.
3. Dr. H. Chaudhuri.
4. Dr. P. K. Kichlu.
5. Dewan Anand Kumar.
6. Mr. P. N. Mehra.
7. Dr. S. D. Muzaffar.
8. Dr. Vishwa Nath.
9. Dr. A. N. Puri.
10. Dr. Zia-ud-Din.

Patna University.
1. Prof. M. Qamrud Doja.
2. Prof. Basudeva Narayana.
3. Prof. Romesh Chandra Roy.

University of Travancore.
Dr. K. L. Moudgill.

Indian Association for the Cultivation of Science, Calcutta.
1. Prof. K. Banerjee.
2. Dr. S. C. Sirker.

Institute of Plant Industry, Lahore.
Dr. A. Sreenivasan.

Indian Botanical Society.
1. Dr. K. Bagchee.
2. Prof. M. O. P. Iyengar.

Carmichael Medical College Hospitals.
Dr. S. K. Basu.

Jodhpur State (Dept. of Public Health)
Mr. K. M. Mehta.

Government of Bihar (Department of Public Health and of Education).
1. Prof. M. Qamrud Doja.
2. Prof. G. K. Ghosh.
3. Mr. K. Mitra.
4. Prof. Ramesh Chandra Ray.

Government of India (Department of Industries and Civil Supplies).
1. Sir S. S. Bhatnagar.
2. Dr. S. Siddiqui.

7. PROGRAMME OF THE SESSION

The thirty-first session of the Indian Science Congress opened on January 3, 1944 and closed on January 6, 1944.

The inaugural meeting was held on Monday, January 3, 1944, at 11 A.M. in St. Stephen's College Hall, Delhi. Sir Maurice Gwyer, K.C.B., K.C.S.I., D.C.L., LL.D., Vice-Chancellor, University of Delhi as Chairman of the Reception Committee welcomed the delegates and the members, and requested His Excellency the Viceroy to open the Congress.

With the permission of His Excellency, after the welcome address, Professor A. V. Hill, Secretary of the Royal Society of London, held a special meeting of the Fellows of the Society (with the rest of the assembly as visitors) and obtained the signatures of some of the Fellows of the Society, who could not sign in the Charter Book of the Society in London.

This meeting being over, His Excellency the Viceroy opened the Proceedings of the Session. After His Excellency's speech, the President delivered his address.

At the close of the inaugural meeting, Lt.-General Sir Clarence Bird, K.C.I.E., C.B., D.S.O., Master-Central of the Ordnance in India, addressed the gathering on the scientific work and organisation of the M.G.O. Branch of the Indian Army.

The PRESIDENTIAL ADDRESSES of the Sections were delivered as follows :—

Tuesday, January 4th : 10 A.M., Agricultural Sciences ; 10-45 A.M., Engineering and Metallurgy ; 11-30 A.M., Zoology and Entomology ; 12-15 P.M., Geology and Geography.

Wednesday, January 5th : 10 A.M., Psychology and Educational Science ; 10-45 A.M., Mathematics and Statistics ; 11-30 A.M., Physiology ; 12-15 P.M., Botany.

Thursday, January 6th : 10 A.M., Chemistry ; 10-45 A.M., Medical and Veterinary Sciences ; 11-30 A.M., Physics, 12-45 P.M., Anthropology and Archaeology.*

DISCUSSIONS were held as follows. A general discussion was held on

Monday, January 3rd : at 3-30 P.M. on the 'Place of Science in the Indian Educational System', (sponsored by the Sub-Committee on Science and its Social Relations) at the University Meeting Room.

List of Discussions

Tuesday, January 4th : 12 NOON TO 1-30 P.M.

Subject	*Section.*
1. Food economics	Physiology.
2. Ethnology in Indian Museums ..	Anthropology and Archaeology.
3. Mental life as pictured in contemporary Psychology.	Psychology and Educational Science.
3-30 P.M. TO 5 P.M.	
4. Locusts and the species problem	Zoology and Entomology.
5. Science and practice of soil tillage in India.	Agricultural Sciences.
6. Electro-Chemical Industries ..	Engineering and Metallurgy and Chemistry (jointly).

Wednesday, January 5th : 12 NOON to 1-30 P.M.

7. Zoology and the food problem ..	Zoology and Entomology.
8. Methods for the improvement of yields of paddy.	Agricultural Sciences.
9. Correlation of Stone Age Culture of India.	Anthropology and Archaeology and Geology & Geography (jointly).
10. Achievement tests and accomplishment quotient and their educational applications.	Psychology and Educational Science.

* In the absence of the President of this Section, the Address was read by Mr. P. Deraniyagala, Chairman of the meeting.

Thursday, January 6th : 12 NOON to 1-30 P.M.

11.	Manufacture of photographic materials in India.	Chemistry and Physics. (jointly).
12.	Standardisation of certain terms in Indian Geology.	Geology and Geography.
13.	Insecticides	Chemistry and Agricultural Sciences. (jointly).
14.	Position of Physiology as an independent science in India.	Physiology.

The following POPULAR LECTURES were delivered :—

January 4th, at 6 P.M.

Architectural education in India by Mr. W. W. Wood, Principal, Delhi Polytechnic.

January 5th, at 6 P.M.

Scientific organisations—official and non-official—in the United Kingdom by Prof. A. V. Hill, Secretary, Royal Society of London.

January 6th, at 6 P.M.

Food and the food crisis by Dr. B. C. Guha, Ghose Professor of Applied Chemistry, Calcutta University.

Special lectures and demonstrations were arranged as follows :—

January 4th :

1. 'Chemists in Government Service' by Dr. H. R. Ambler, Chief Inspector of Military Explosives, Kirkee (in the section of Chemistry), at 10 A.M.
2. 'Mobile producer gas plants' by Dr. Lal C. Verman, Assistant Director of Research Board of Scientific and Industrial Research, Delhi, at 2-30 P.M.
3. 'Produce gas in War effort' by Dr. H. B. Dunnicliff of War Transport Department, New Delhi, at 2-30 P.M.
4. Demonstrations at the laboratories of the Director of Scientific and Industrial Research, in the afternoon.
5. 'Development of Indo-Muslim Architecture as illustrated by Delhi Monuments' by Khan Bahadur Zafar Hasan at 3-30 P.M.

January 6th :

6. 'Cosmic Rays' by Prof. H. J. Bhabha of Cosmic Ray Research Unit, Indian Institute of Science, Bangalore, at 3-30 p.m.

Meetings of the Committees were held as follows :—

SECTIONAL COMMITTEES met at 2 P.M. on January 3rd and at 10 A.M. on the succeeding days till January 6th.

SUB-COMMITTEE ON SCIENCE AND ITS SOCIAL RELATIONS met at 3 P.M. on January 3rd.

COUNCIL met at 2-30 P.M. on January 3rd.

EXECUTIVE COMMITTEE met at 2-30 P.M. on January 2nd and January 4th.

GENERAL COMMITTEE met at 2-30 P.M. on January 5th.

The following SOCIAL FUNCTIONS were held:—

January 3rd:

4-30 P.M.: Tea Party by the Reception Committee at the University Gardens.

6-30 P.M.: Musical Entertainment organised by the Reception Committee at the St. Stephen's College Hall.

VISITS to the following institutions were arranged:

January 5th, at 2-30 P.M.

(1) Delhi Cloth Mills.
(2) Imperial Agricultural Research Institute.
(3) Transmitter and Broadcasting House, All-India Radio.

January 6th, at 2-30 P.M.

Same programme as above.

The following *Scientific Societies* held their Annual Meetings:

January 3rd, at 1-30 P.M.

(1) Society of Biological Chemists, India.
(2) Indian Physical Society.
(3) Indian Psychological Association.
(4) Physiological Society of India.
(5) Entomological Society of India.
(6) Indian Botanical Society.
(7) Annual General Meeting of the Indian Pharmaceutical Association (continued on January 4th).

January 4th, 1-30 P.M.

(8) Indian Society of Soil Science.
(9) Institute of Chemistry of Great Britain and Ireland (Indian Section).
(10) Indian Ecological Society.
(11) Indian Chemical Society.

At 2-30 P.M. there was a Conference on Food and Nutrition under the auspices of the All-India Nutrition Board.

Prof. S. K. Mitra, General Secretary of the Indian Science Congress Association, broadcast a talk on 'Indian Science Congress—its forthcoming Session', from the Delhi Station at 8-30 P.M., on January 2, 1944.

8. OPENING PROCEEDINGS

Sir Maurice Gwyer, Chairman of the Reception Committee delivered the following welcome address:—

This is indeed an auspicious day for the University of Delhi. We welcome first our long-lost Chancellor whom we have not seen for over 12 years; and we welcome also the Indian Science Congress, that notable association of Indian scientists, who are meeting for the first time in the capital city of India. We welcome, too, a body of most distinguished strangers, who are here to testify to that unity of science which transcends all national and racial barriers and especially among them Professor Hill, Fellow and Secretary of the Royal Society, and Member of the House of

Commons, who is, in a few moments by a kind of magic, to transform this hall into the Council Chamber of the Royal Society itself and to admit to that august body, with the traditional ceremony appropriate to the occasion, those Indian scientists whom the Royal Society has honoured, as it has honoured itself, by enrolling among its Fellows.

The University of Delhi is among the younger of Indian universities and it is only recently that it has begun to organize and develop on progressive lines its science school and its science teaching. The presence here today of His Excellency the Chancellor and of this great body of scientists will be to the University both an encouragement and an inspiration in the tasks which it has undertaken. And I cannot but think it of happy augury that, the University not having yet a hall of its own large enough for such proceedings as this, it is the oldest Arts college of the University which is so hospitably receiving us. The conflict which was once supposed to exist between science and humanism is for all wise men at an end ; and indeed if the aim of both is, as it must be, the spread of learning and the establishment of truth, it is strange that there should ever have been any question of rivalry between them. Each learns something from the other, each makes the other more fruitful ; and from this happy union may a new generation arise, reflecting the beauty and vigour of both its parents.

Indian science has already achieved a position second to none in the world, and Indian men of science have it in their power to make a contribution to the future welfare of India almost beyond human computation. They can transform the face of India, they can multiply its wealth, they can solve the problems of ignorance and poverty ; and who knows whether they may not even be able to solve the most intractable of all, India's constitutional problems? It is the earnest prayer of all who have the happiness and welfare of this country at heart that all these problems, surveyed in the calm and serene atmosphere of science by men consecrated to the search for truth and nothing but the truth, with minds free from prejudice or bias, may find a solution, or at least the beginnings of a solution, at the meetings this week in Delhi.

By the irony of circumstances, war, that great enemy of human progress, affords the most powerful stimulus to scientific research that we know ; but good can come out of evil, as war is followed by peace ; and that part of the world which still loves peace and still believes in human personality, in the dignity of man and in honest dealing between nation and nation, will benefit hereafter from the labours of scientists to put new and ever more potent weapons in its hands to defeat the enemies of mankind. For those and for the many other blessings which, by the goodness and mercy of God, men of science have bestowed upon us, we tender them our gratitude ; and we hope that their labours this week and the discussions and contacts which a gathering like this makes possible will bear fruit a hundredfold.

It is, Sir, very fitting that you should be here today to open this Congress. Yourself the grandson and great-grandson of distinguished scientists, you have, after leading victorious armies, returned to India, determined to prove, as all your public utterances show, that peace has victories no less renowned than war. In this great task you will, I know, receive the help and co-operation of every scientist in India ; and I believe that they in their turn may look with confidence to Your Excellency for guidance and encouragement. Science knows no politics, and here all are labourers in a common field.

Sir, on behalf of the Reception Committee, of the University of Delhi and of all those present today, I thank you for coming here on this historic occasion. I have the honour to request Your Excellency formally to open the Congress ; but first I will ask you to permit Professor Hill to exercise the powers which have been delegated to him by the President of the Royal Society and to perform a ceremony which is without precedent not only in India but also, I believe, in the history of the Royal Society itself.

His Excellency the Viceroy in declaring the Congress open delivered the following speech :—

It is a great privilege to have been present today to witness the unique ceremony of a meeting of the Royal Society outside England ; to hear the greetings of its President and other eminent Fellows to their Indian colleagues ; and to witness the admission of new Fellows to the Society.

It may interest you to know that it is just over 100 years ago since the first representative of Eastern science, an Indian gentleman of great engineering ability, was admitted as a Fellow of the Royal Society.

The occasion is also made memorable by the presence of Professor Hill himself, the Secretary of the Royal Society, a physiologist of international repute, who has come to India to establish a closer touch between scientists in the United Kingdom and in India, with special reference to India's problems of post-war development. Science—knowledge—should mean peace and progress, but in these days of turmoil, even men of science have had to take a hand in the dealing of destruction ; and Professor Hill is closely connected with the war effort. That he has been allowed at our request to leave England and come to India at this time is a measure of the importance attached to the improvement of the contacts between scientists in the United Kingdom and India.

Nothing in my career has fitted me to address so distinguished a gathering of scientists. I certainly have no scientific qualifications to do so ; though I have an ancestral connection with the Royal Society, as Professor Hill has told you. My great-grandfather and grandfather were both Fellows ; and I was lately privileged by the kindness of Professor Hill to see facsimiles of their signatures to the Obligation to which we have just listened. My great-grandfather was, I believe, quite a distinguished scientist who discovered a mineral called Wavellite ; I mean he discovered it, and the famous chemist Sir Humphrey Davy called it Wavellite. I was always a little dubious about my grandfather's fellowship ; he was a roving soldier of fortune who fought in India, in Spain during the Peninsular War, and for Chile and Mexico in their wars of liberation. He was a man of wide knowledge and experience, but I always wondered how he found time to acquire the deep scientific learning associated today with fellowship of the Royal Society. Professor Hill, when I enquired of him in London whether the records of the Society showed in what particular branch of science my grandfather was so distinguished, broke it to me gently that in those far-off days it sometimes happened that members got their sons elected without any very special scientific qualification, other than a kindly presumption that they had inherited their parent's scientific turn of mind. That expectation might have been fulfilled in my grandfather, who had an enquiring mind, some considerable knowledge of geology, and much literary ability, but I am afraid he transmitted to his sons and grandsons his roving and military genes rather than any scientific ones.

Though I have never regretted that I had a classical education, I have always regretted that I had not at least a good grounding in science; and I have always had a profound admiration for men of science. It is a little curious to mark the attitude of the bulk of ignorant mankind, such as myself, towards men of science. In the earliest days of civilisation, they were revered as magicians and given pride of place and power, as in ancient Egypt. I think they have always continued to hold a high place in the East; but in the West at one period there was great suspicion of the man of science who was classed as a sorcerer, a wizard or a warlock, had to practise in secret, and was liable to be burnt at the stake. Since those dark days the man of science has had a freer hand; and our general complaint against him now might be that he has gone too fast for us; and has poured out inventions quicker than we can assimilate them. A famous English poet wrote nearly 100 years ago that: "Science moves, but slowly, slowly, creeping on from point to point". Had he written now, I feel that his line would have run more like this: "Science shoves on quickly, quickly, bustling us from post to post". There is much to be said for the old leisurely days and the old leisurely ways before the scientist began his assault on space and time. Worse still, his inventions have sometimes got into wrong hands. A domineering bully like the Prussian should never have been entrusted with an aeroplane; nor an ambitious barbarian like the Jap with a battleship.

Still there is nothing more unprofitable than to try to turn back the wheels of time. We cannot trick the imp back into the bottle as did the sailor of the Arabian Nights. We must go on now and must enlist the help of the scientists to control the genii they have raised, and to bring order into this new world for which they are so largely responsible. They have put before us great possibilties to a wider, fuller, healthier, and more prosperous life, if we can use their gifts aright.

India, one of the oldest civilisations, has perhaps felt the impact of modern science later and less than any other great people. A large proportion of her population still lives the old life untouched by the vast changes of this century. Her realm has been of the spirit rather than of the earth. It may be said of the West hereafter that we took too much from India materially and too little spiritually.

But if India is to play the part in the world to which her size, her population, her history and her position entitle her, she too must make every possible use of scientific advancement. She has already produced many great scientists, she bears many more in her fertile womb. Her contributions to science have always been on the side of peace and progress. She has everything to gain by combining modern science with her old culture, indeed her traditional outlook should enable her to make an increasingly fine and characteristic contribution to natural knowledge. Indian science has made in fact a very remarkable stride forward during the last 25 years, as is shown by the foundation of many new societies, new journals and new departments of science in universities and under Government.

In this war science has played a great rôle in India as elsewhere. It has made a splendid contribution to maintaining the health of the fighting men, through the activities of such bodies as the Malaria Institute, the Indian Research Fund Association, the Nutrition Laboratories at Coonoor, and others. It has also played an important part in munitions production and in solving problems of supply. As an ex-Commander-in-Chief, I should like to thank Indian science for the invaluable assistance it has given to the armies in the field.

It must play a great part also in post-war development. The coming years will be vital to India. She must learn to make use of her abundant resources with the aid of science. Science is the most international of all human interests. Professor Hill has himself said in an address elsewhere: "I believe that the pursuit of knowledge for the welfare of mankind is one of the greatest agents for goodwill between men in every land." It is in that belief that he is here today.

This Session of the Indian Science Congress has a momentous task to perform: to discover how best to bring the aid of science to the development of India's great resources in agriculture and industry, to the improvement of health and to social advancement and prosperity. This Science Congress is a body of high repute, with a great and growing membership and influence. Gentlemen, I wish all success to your deliberations. I declare the Congress to be open and ask Professor Bose to give his presidential address.

The President, Professor S. N. Bose then delivered his address.*

At the close of the meeting Prof. S. K. Mitra, General Secretary of the Indian Science Congress Association proposed votes of thanks to H. E. the Viceroy and to the Reception Committee with the following speech:—

We are extremely grateful to His Excellency the Viceroy for coming here this morning to open the proceedings of the thirtyfirst Session of the Indian Science Congress. It has been customary in all ages and in all countries for the royalty and the wealthier section of the community to be the patrons of arts, science and learning. It is therefore but proper and natural that His Excellency, as representative of His Majesty the King Emperor, should come here to inaugurate our Proceedings. We would, however, love to think that His Excellency is in our midst today, not as a matter of duty because he is the administrative head of the country—but because he is a soldier and he thinks the scientists as his comrades-in-arms, who have helped him an fighting the Axis powers abroad, and who will now help him in fighting within the country the Axis combination—Poverty, Ignorance and Disease. I would remind you that His Excellency had some time ago referred to the urgency of fighting and exterminating this combination. On the eve of his departure from England, His Excellency said at the Pilgrims Luncheon: "It has always seemed to me a curious fact that money is forthcoming in any quantity for the war, but no nation has ever yet produced money on the same scale to fight the evils of peace—poverty, lack of education, unemployment and ill-health. When we are prepared to spend to this end, our money and our efforts as freely and with the same spirit as against Hitler, we shall really be making progress. In the country to which I go, these evils have to be met on possibly a greater scale than elsewhere." In the name of the Indian Science Congress Association, which is a representative body of scientific workers in India, I can assure His Excellency, that the scientists of this country, are always eager to lend their fullest support to his efforts in fighting these evils. Ladies and Gentlemen, will you now kindly join me in very sincerely and heartily thanking our soldier and fighter Viceroy for his interest in the Indian Science Congress and for the trouble he has taken, in spite of his multifarious duties, to come here to open our proceedings.

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* Published in Part II of the Proceedings.

Ladies and Gentlemen, I have another pleasant duty to perform, namely to propose vote of thanks to the University of Delhi and to the Chairman and the members of the local Reception Committee. You are perhaps aware that this Session of the Science Congress was originally arranged to be held at Trivandrum under the auspices of the University of Travancore. Due to unforeseen difficulties, however, over which the authorities of Travancore had no control and, in spite of their best efforts, it was found not possible to hold the session there and the venue had to be abandoned. The Executive Committee of the Association, therefore, approached the University of Delhi, and the Vice-Chancellor, Sir Maurice Gwyer, very kindly agreed to arrange for the Session under the auspices of the University. We are very grateful indeed for the arrangements that have been made and that at such short notice. As one who has experience of organising Science Congress Sessions more than once, I can appreciate the difficulties which the Local Committee had to face and overcome. But fortunately, they have at the helm as Chairman, Sir Maurice Gwyer and as Secretaries, Sir S. S. Bhatnagar and Dr. Kothari. With such a combination the Session is bound to be a success. In fact Ladies and Gentlemen, personally I had never had any doubt about the success of the Session because, from the very beginning I was fortunate enough to enlist the support of Sir Bhatnagar. I have never known a Bhatnagar enterprise to fail.

May I now request you all to join me in thanking the Chairman, the Treasurer, the Secretaries, the Assistant Secretaries and the other members of the Local Reception Committee on behalf of the Indian Science Congress Association.

APPENDIX—Address by Lt.-General Sir Clarence Bird, K.C.I.E., C.B., D.S.O., Master-General of the Ordnance in India.

I greatly appreciate the opportunity of addressing you on this important occasion and of giving you a brief outline of the work of the M. G. O. in its scientific aspects.

First of all, may I explain that the M. G. O. is the Administrative Officer on the staff of H. E. the Commander-in-Chief responsible for providing the necessary weapons, technical equipment and clothing for the Army, and certain items for the Navy and Air Force. In parenthesis I may say that the existence of some doubt regarding my responsibilities is clear from the fact that I am frequently addressed as the Master-General of the Ordinances!

Prior to the war, these responsibilities included control of the then existing Ordnance factories, but when the Supply Department was created the control of these factories was transferred *en bloc* to the new department and thus provided it with a nucleus organisation on which to expand.

I am therefore not responsible for production but I am responsible for the calculation of the necessary requirements, the preparation of specifications, and drawings if necessary, placing of demands on the Supply Department, inspection, storage and distribution.

There are broadly two distinct aspects in the scientific work involved in the production of these requirements.

Firstly, there is the field of scientific research covering new requirements and the scientific investigation connected with them. Such requirements are worked out and formulated in general terms in their military aspect, and presented to the scientist with the request that he will get to work on them. In the past, this aspect has been covered almost entirely by the United Kingdom, the United States, and those Dominions where industries of the highly scientific type were already established. This arrangement has satisfied the hitherto prevailing conditions, but in consequence, requirements *in that form* have seldom been put to Indian scientists and therefore the necessary mechanism has not been developed to any appreciable extent.

The second aspect covers the field of scientific development of technique and improvement of production standards, with which the M. G. O.'s Branch has hitherto been mainly concerned. A consistent, if unobtrusive, policy has been followed of endeavouring to achieve improvement in these directions which has had a steady and increasing effect on the industrial economy of this country.

During the past four years we in India have had to deal with a succession of technical difficulties as they have arisen and the day-to-day application of scientific technique to existing and new industries has absorbed almost all our attention and energy. Scientific research of the kind to which I have already referred has, therefore, had to give place to the pressing need for finding prompt production of the stores and equipment of all kinds.

Nevertheless, India can be proud of what has been accomplished in making the best of her resources in difficult circumstances. Apparatus, scientific appliances and materials have been limited and to a considerable extent she has been cut off from those international scientific contacts which mean so much to the scientific worker. Nevertheless, noteworthy results have been achieved in the scientific adaptation of our main industries to production on a vast scale of many new types of stores and equipment.

The Ordnance Services have contributed their quota to the development of technique in Indian industries to their permanent benefit. This result would, however, have been impossible without the willing co-operation of industry, which I am glad to acknowledge. Furthermore, the contribution of the Ordnance Services is largely due to those scientists and technologists who have been recruited from industry for the duration of the war. While Government control, with its official regulations and restriction is no doubt regarded at least with suspicion, we have, nevertheless, handed out in full measure valuable technical assistance to many concerns with every prospect of a permanently good effect. In the textile industries, we have provided a stimulus and, to a modest degree, technical aid that should prove of lasting value.

In our development of the silk parachute, we feel that we have made a real contribution to the future of the Indian silk industry. We have helped the metal industries to develop stores which used to be imported and we hope that in assisting them in points of design and processing we may have enabled some of them to establish themselves securely for the future.

From small beginnings some years ago in very cramped quarters the organisation dealing with this aspect of the activities of the M. G. O. has now grown to large dimensions and is centred on the fine technical laboratories established at Cawnpore which were opened in April last by H. E. the Viceroy when he was Commander-in-Chief. It functions under the general direction of the Controller-General of Inspection, Brigadier Woolfe and, until recently, Mr. C. O. Tattersall, who has now joined my personal staff as Scientific Adviser, was the Director of Laboratories and is now in charge of Technical Co-ordination. Both these officers are with us to-day and I would express my indebtedness to them for all that they have done.

Sir Shanti Swarup Bhatnagar, as a member of the G. H. Q. Supply Department Committee of which I am Chairman, is closely associated with our work and I take the opportunity of expressing to him my thanks and appreciation for his valuable help and co-operation.

We have now reached a phase in the war where research and development are assuming greater importance. New problems are arising, new ideas are flowing in from other theatres of war as the result of experience, and with the development of India as a base for operations her scientific resources will be called on increasingly to deal with them.

In that connection we welcome particularly the visit of Prof. Hill, whose wide experience and advice will be of incalculable value to us.

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9. RECORDS OF COMMITTEE MEETINGS

General Committee

A meeting of the General Committee of the Indian Science Congress Association was held at 2-30 P.M. on Wednesday, January 5, 1944, in the University Building, Delhi, with Professor S. N. Bose, the President, in the chair. The following items of business were transacted :

(1) The minutes of the last meeting of (*a*) the General Committee held on January 4, 1943, and of (*b*) the Special Meeting of the General Committee held on

January 2, 1943, to discuss Science and its Social Relations with special reference to the work of the Sub-Committee on 'Science and its Social Relations' (both held in the University College of Science, Calcutta), were read and confirmed.

(2*a*) The General Secretary read a letter from the Minister of Education, Afghanistan, informing that a delegation of three members of the Faculty of Medicine, Kabul, has been sent to the Session, and he informed that on behalf of the Association he had accorded them a warm welcome.

Note: The delegation with the letter reached too late for announcement on the opening day.

(2*b*) The General Secretary read a telegraphic message of goodwill from Tata Chemicals Limited.

(3) The President announced the names of seven members elected to the Executive Committee under Rule 16, and of seven members elected to the Council under Rule 20, for the year 1944-45:

Executive Committee.	*Council.*
1. Prof. S. P. Agharkar, Calcutta.	1. Sir Cyril S. Fox, Calcutta.
2. Prof. H. Chaudhuri, Lahore.	2. Dr. A. C. Joshi, Benares.
3. Mr. J. J. Ghandy, Jamshedpur.	3. Prof. H. K. Mookerjee, Calcutta.
4. Dr. John B. Grant, Calcutta.	4. Dr. B. Mukerji, Calcutta.
5. Prof. B. C. Guha, Calcutta.	5. Dr. B. Narayana, Patna.
6. Prof. P. C. Mitter, Calcutta.	6. Dr. Mata Prasad, Bombay.
7. Mr. W. D. West, Calcutta.	7. Mr. L. Rama Rao, Bangalore.

(4) The President announced that the Thirty-second Meeting of the Indian Science Congress would be held at Nagpur under the auspices of the University of Nagpur from January 2 to January 8, 1945.

(5) The nomination by the Executive Committee of Sir Shanti Swarup Bhatnagar, O.B.E., D.Sc., F.R.S., F.Inst.P., F.S.C.I.(Hon.), F.N.I., Director of Scientific and Industrial Research, Government of India, as General President for the year 1945, was confirmed.

(6) The nomination by the Executive Committee and the Council of Professor A. V. Hill, F.R.S., M.P., Secretary, Royal Society of London, as Honorary Member of the Association, was confirmed.

(7) The appointment by the Executive Committee of Professor M. Qureshi, Ph.D., F.N.I., Head of the Deparment of Chemistry, Osmania University, Hyderabad-Deccan, as General Secretary, was confirmed.

(8) The President announced the names of the Sectional Presidents and Recorders of the Thirty-second Meeting as follows:

Section.	*President.*	*Recorder.*
1. *Mathematics and Statistics.*	Dr. B. N. Prasad, Department of Mathematics, Allahabad University.	Prof. K. B. Madhava, Professor of Mathematical Economics and Statistics, Mysore University.
2. *Physics* ...	Dr. R. C. Majumdar, Research Physicist, Bose Rsearch Institute, Calcutta.	Dr. R. M. Chaudhri, Chairman, Department of Physics, Muslim University, Aligarh.
3. *Chemistry* ...	Prof. K. Venkataraman, Mody Professor and Director of the Department of Chemical Technology, Bombay University.	Dr. S. Siddiqui, Assistant Director of Research, B.S.I.R., Delhi.
4. *Geology and Geography.*	Mr. N. N. Chatterjee, Lecturer in Geology, Calcutta University.	Mr. L. S. Krishna Murthy, Petrologist, Geological Survey Department, Hyderabad (Deccan).
5. *Botany* ...	Prof. G. P. Majumdar, Professor of Botany, Presidency College, Calcutta.	Dr. T. S. Mahabale, Department of Biology, Gujarat College, Ahmedabad.
6. *Zoology and Entomology.*	Dr. H. N. Ray, Protozoologist, Imperial Institute of Veterinary Research, Mukteswar-Kumaun.	Mr. M. Rahimullah, Department of Fisheries, H. E. H. the Nizam's Government, Hyderabad (Deccan)
7. *Anthropology and Archaeology* ...	Sir Theodore Tasker, Superviser, I.C.S. Camp, Dehra Dun.	Dr. A. Aiyappan, Offg. Superintendent, Government Museum, Madras.

Section.	*President.*	*Recorder.*
8. *Medical and Veterinary Sciences.*	Prof. S. W. Hardikar, Professor of Pharmacology, Osmania Medical College, Hyderabad (Deccan).	Dr. K. C. Sen, Officer-in-Charge, Animal Nutrition Section, Imperial Veterinary Research Institute, Izatnagar.
9. *Agricultural Sciences.*	Prof. N. V. Joshi, Honorary Professor of Microbiology and Biochemistry, Fergusson College, Poona.	Dr. P. V. Sukhatme, Statistician, Imperial Council of Agricultural Research, New Delhi.
10. *Physiology* ...	Dr. B. Mukerji, offg. Director, Biochemical Standardization Laboratory, Government of India, Calcutta.	Dr. Khemsingh Grewal, Professor of Pharmacology, King Edward Medical College, Lahore.
11. *Psychology & Educational Science.*	Mr. B. Kuppuswamy, Lecturer in Psychology, Mysore University.	Dr. Indra Sen, Lecturer in Psychology and Philosophy, Hindu College, Delhi.
12. *Engineering and Metallurgy.*	Prof. H. P. Philpot, Professor of Engineering and Principal, Engineering College, Benares.	Mr. B. R. Kagal, Land and Development Officer, New Delhi.

(9) The following were elected Members of the Sectional Committees for the year 1944-45 :

Mathematics and Statistics ..	1.	Mr. F. C. Auluck, Lecturer in Mathematics, Delhi University.
	2.	Mr. V. V. Narlikar, Head of the Department of Mathematics, Benares Hindu University.
Physics	1.	Dr. A. K. Dutta, Lecturer in Physics, Delhi University.
	2.	Dr. D. V. Gogate, Professor of Physics, Baroda College.
Chemistry	1.	Mr. M. Q. Doja, Professor of Organic Chemistry, Science College, Patna.
	2.	Dr. S. K. Majumdar, Professor of Chemistry, Presidency College, Calcutta.
Geology and Geography ..	1.	Dr. Kazi S. Ahmad, Department of Geography, Muslim University, Aligarh.
	2.	Mr. W. B. Metre, Geologist, Burmah Oil Company, Digboi, Assam.
Botany	1.	Dr. B. K. Kar, Plant Physiologist, Bose Research Institute, Calcutta.
	2.	Dr. B. P. Pal, Imperial Economic Botanist, Imperial Agricultural Research Institute, New Delhi.
Zoology and Entomology ..	1.	Dr. Hamid Khan, Game Warden, Punjab, Lahore.
	2.	Dr. J. Dayal, Lecturer in Zoology, Lucknow University.
Anthropology and Archaeology.	1.	Mr. N. Chaudhuri, Government Translator, Calcutta.
	2.	Mr. D. Sen, Professor of Geography, Vidyasagar College, Calcutta.
Medical and Veterinary Sciences.	1.	Mr. S. K. Basu, Lecturer in Anatomy, Carmichael Medical College, Calcutta.
	2.	Dr. B. Mukerji, Offg. Director, Biochemical Standardization Laboratory, Government of India, Calcutta.
Agricultural Sciences ..	1.	Dr. S. P. Raychaudhuri, Chemical Laboratory, Dacca University.
	2.	Dr. T. S. Sabnis, Principal, Cawnpore Agricultural College.
Physiology	1.	Dr. B. Ahmad, Professor of Organic Chemistry, University of the Panjab, Lahore.
	2.	Dr. K. Biswas, Superintendent, Royal Botanic Garden, Howrah.

Psychology and Educational Science.	1. Mr. A. N. Basu, Head of the Teachers' Training Department, Calcutta University.
	2. Mr. T. K. N. Menon, Principal, Secondary Teachers' Training College, Baroda.
Engineering and Metallurgy	1. Mr. N. N. Sen, Professor of Chemistry, Bengal Engineering College, Howrah.
	2. Dr. S. K. Sircar, Chemical Engineer, Kusunda, Manbhum District.

(10) The Audited Statement of Receipts and Payments for the year ending 30th November, 1943 was adopted.

(11) The Budget Estimates for the year 1st December, 1943 to 30th November, 1944 were approved.

Note: Extracts from the minutes of the meeting of the Finance Committee relating to the above two items were circulated at the meeting for information of the members.

(12) The following votes of thanks were unanimously adopted :

(*a*) To His Excellency the Viceroy for consenting to be the Patron of the Association for 1944 Session at Delhi and for opening the Session, proposed by the President.

(*b*) To the Vice-Chancellor and the University of Delhi, proposed by Professor S. K. Mitra.

(*c*) To the Local Reception Committee, proposed by the President.

(*d*) To the Local Secretaries, proposed by Professor S. K. Mitra.

(*e*) To the Treasurer of the Local Reception Committee, proposed by Professor J N. Mukherjee.

(*f*) To the Volunteers, proposed by Professor S. K. Mitra.

(*g*) To the President, proposed by Professor J. N. Mukherjee.

(*h*) To the Sectional Presidents, proposed by Professor S. K. Mitra.

(*i*) To the General Secretaries, proposed by Professor P. C. Mitter.

(*j*) To the Treasurer, proposed by Professor P. C. Mitter.

2. Council

A meeting of the Council was held at 2-30 P.M. on Monday, January 3, 1944, in the University Building, Delhi, with Professor S. N. Bose, in the chair. The following items of business were transacted :

1. The minutes of the meeting of the Council held on January 2, 1943 at Calcutta, were read and confirmed.

2. In accordance with Rule 8 the recommendation of the Executive Committee that Professor A. V. Hill be elected a Honorary Member of the Association was approved.

3. Considered the proposals for the establishment of the National Research Council framed by the National Institute of Sciences of India. (Copy of the proposal circulated to the members of the Council.)

Resolved that the proposals be generally approved.

4. Read a letter from the Minister of Education intimating the sending of a delegation consisting of three members from the Faculty of Medicine, Kabul, to the Indian Science Congress.

Note: The delegation with the letter could not meet the General Secretary before the Opening Ceremony of the Session.

Resolved that a letter be sent to the Minister of Education, Afghanistan, conveying sincere thanks for his co-operation and hoping that such delegations would bring the men of science of two countries nearer and to their mutual benefit.

Resolved further that the matter be reported to the General Committee.

3. Executive Committee

Nine Meetings of the Executive Commmittee were held during the year 1943-44. The following are the important items of business transacted. (Only abstracts of the resolutions are given. Routine matters and business reported elsewhere in these pages are not included.)

1. Rai Bahadur Dr. S. L. Hora was nominated member of the Finance Committee. (22-2-43).

2. Messrs. Tata Iron & Steel Co., Ltd. were elected the first Benefactor of the Association under the new rule for their munificent donation of Rs. 5,000 to the Association. (22-2-43).

3. The death of Mr. John van Manen who was Managing Secretary of the Association for a long time was mourned. (20-4-43).

4. Dr. M. S. Krishnan was nominated as an Additional Member of the Council of the National Institute of Sciences of India for the year 1943. (20-4-43).

5. In regard to the resolutions adopted by the different Sections at the 30th Sessions of the Congress at Calcutta (see pages 32-34 of Part I of the Proceedings of the 30th Indian Science Congress), the following actions were taken. (20-4-43).

Section of Anthropology and Archaeology—

Copies of the resolutions Nos. 1 and (2) were forwarded to the Educational Adviser to the Government of India and a copy of the resolution No. 3 was forwarded to the Secretary, Royal Asiatic Society of Bengal, Calcutta.

Sections of Medical and Veterinary Sciences, Zoology and Entomology, Botany any Chemistry—

A copy of the resolution was forwarded to the Secretary, Imperial Council of Agricultural Research.

Sections of Geology and Geography, Botany, Agricultural Sciences and Engineering and Metallurgy—

A copy of the full resolution adopted jointly by the above Sections was forwarded to the Secretary, Department of Education, Health and Land, Government of India, and a copy of part (*b*) of the resolution was forwarded to the Secretary, Imperial Council of Agricultural Research.

6. Invitations were extended to the following Scientific Bodies requesting their representation at the Session of the Science Congress. (20-4-43).

(1) British Association for the Advancement of Science, London.
(2) American Association for the Advancement of Science, Washington.
(3) Pacific Science Association, California (U. S. A.).
(4) Canadian Association for the Advancement of Science, Ottawa.
(5) South African Association for the Advancement of Science, Johannesburg.
(6) Australian Association for the Advancement of Science, Sydney.
(7) Academia Sinica, Chungking, China.

7. Professor S. N. Bose was nominated as an Additional Vice-President of the Council of the National Institute of Sciences of India for the year 1943. (24-5-43).

8. As an emergency measure the following forms and circulars were suspended and instead a memorandum slip was attached to the Blue Book (Lists of Officers and Members) : (24-5-3)

(1) Form for submitting Papers.
(2) Circular inviting nominations for the Executive Committee and the Council.
(3) Circular inviting nominations for Sectional Officers from the members of the Sectional Committees.

9. The measure of the printed matter within a page of the Proceedings was increased in order to effect saving in paper. (31-8-43).

10. The synopses of the lectures to be delivered by Dr. Motwani were generally approved and it was pointed out that in every lecture Dr. Motwani should make it clear that the views expressed by him were his own views and that the Indian Science Congress Association did not accept any responsibility for the opinion expressed (*vide* Item No. 5, page 32 of Part I of the Proceedings of the 30th Session of the Science Congress). (20-12-43).

11. Professor S. N. Bose and Professor M. Qureshi were nominated an Additional Vice-President and an Additional Member respectively of the Council of the National Institute of Sciences of India for the year 1944. (2-1-44).

4. Sub-Committee on Science and its Social Relations

The Sub-Committee on 'Science and its Social Relations' met during the session on January 3, 1944, at 2-30 P.M. in the Hall of the Delhi University. Prof. S. N. Bose was in the chair. The following items of business were transacted :

1. Minutes of the meeting held on December 8, 1943, at Calcutta were confirmed.

2. Mr. A. N. Basu presented the annual report as circulated and it was confirmed (report printed below).

3. Dr. K. Motwani submitted the following statement of accounts which was passed. It was further resolved that the thanks of the Sub-Committee be conveyed to Dr. J. B. Grant for undertaking all office expenses in connection with the work of the Sub-Committee.—STATEMENT OF ACCOUNTS.

Receipts	Rs.	A.	P.	*Payments*	Rs.	A.	P.
Previous balance with the Secretary ...	89	9	0	Miscellaneous ...	3	9	0
Grant from the Executive Committee ...	50	0	0	Balance with the Secretary ...	136	0	0
	139	9	0		139	9	0

It was also resolved that from next year funds of the Sub-Committee should be with the Convener and that he should operate the accounts.

4. The Sub-Committee recommended the following names for constituting the Sub-Committee for the next year:

Dr. J. B. Grant
Prof. S. N. Bose
Pandit Jawaharlal Nehru
Prof. S. K. Mitra
Prof. M. Qureshi
Prof. M. N. Saha
Prof. B. C. Guha
Dr. S. C. Mitra
Dr. Gilbert Fowler
Dr. C. N. Acharya
Dr. Kewal Motwani
Dr. Zakir Hossain
Dr. D. M. Sen
Dr. K. C. K. E. Raja
Mr. A. C. Ukil
Prof. Benoy Kumar Sarkar
Mr. A. N. Basu

Dr. J. B. Grant will be the Convener and Dr. K. Motwani and Mr. A. N. Basu Secretaries.

Annual Report of the Sub-Committee

During the year under review the personnel of the Committee (as constituted at the Calcutta Session in 1943) has been as follows:

Dr. John B. Grant
Mr. D. N. Wadia
Pandit Jawaharlal Nehru
Prof. S. K. Mitra
Prof. P. Parija
Prof. M. N. Saha
Prof. B. C. Guha
Dr. S. C. Mitra
Prof. D. D. Kanga
Dr. Gilbert Fowler
Dr. C. N. Acharya
Dr. Kewal Motwani
Mr. A. N. Basu
Mr. A. C. Ukil
Prof. Benoy Kumar Sarkar

Dr. J. B. Grant has been the Convener of the Sub-Committee with Dr. K. Motwani as the Secretary and Mr. A. N. Basu as the Joint Secretary.

2. During the year the Sub-Committee held six meetings.

3. One of the first questions, on which the Sub-Committee was asked to give its opinion related to the proposal for the establishment of a National Academy of Social Sciences moved by Dr. Motwani. After giving careful consideration to the proposal the Sub-Committee expressed the opinion that the initiative for starting such an Academy should be primarily left to workers in the field of social sciences in India.

4. The Sub-Committee also considered and recommended to the Executive Committee the acceptance of the offer of Seth Kewalram Chellaram of Rs. 2,000/- for appointing Dr. Kewal Motwani as a special lecturer under the auspices of the Indian Science Congress Association to deliver a course of three lectures at different Indian universities as suggested by the donor. Dr. Motwani was requested to submit a synopsis of his proposed lectures which he did. Certain

modifications of this synopsis were suggested and Dr. Motwani has revised his synopsis which has now been circulated to the members of the Executive Committee for approval.*

5. The Sub-Committee further considered the ways and means for implementing the purpose for which it was established and adopted the following resolution to which it begs to draw the attention of all those who are interested in the problem of the existing lag between the stage of evolution of our social order and its material environment :

"In order to meet the problems arising out of the increasing impact of science on society, to have an integrated approach to the problems of social life and to co-ordinate the various social sciences, the Universities in India and the Departments of Public Instruction be requested to stimulate and foster a co-ordinated study and research along the following lines :

(*i*) To emphasise the social and international relations of science and of new discoveries and inventions in the curricula of the Faculties of Social Sciences in India and to bring about a closer co-ordination between the present branches of the social sciences now being studied.

(*ii*) To explore the avenues through which the contributions of science may be adapted to the life and welfare of the individual and the nation, without allowing any anti-social applications of science.

(*iii*) To investigate into the causes of the lag between science and its social applications and to offer proposals to assist in its solution.

(*iv*) To integrate the following subjects in the curriculum of the Intermediate and Graduate courses at the Universities :

(*a*) Physical science, including astronomy, with emphasis on the order in which the several facts have become known.

(*b*) Biological and geological science : the elements of plant and animal evolution, development and function.

(*c*) History of scientific discoveries, technology, inventions and their impact on Society.

(*d*) The social sciences, including sociology, anthropology, economics, psychology, with the elements of moral and political philosophy.

(*v*) To give increasing social and scientific bias in primary and secondary education.

(*vi*) To organise adult education with a social and scientific bias.

6. The Sub-Committee drafted a request to the Chairman of the Central Advisory Board of Education for including the following item in their agenda for one of their meetings : "Science and Citizenship in the educational system with special reference to the primary and secondary stages and the ways and means to undertake necessary corrective measures."

In response to the above suggestion the Secretary of the Board requested the Indian Science Congress to submit a concrete scheme for adoption in schools in India. In compliance with this, the following tentative scheme, prepared by Mr. Basu, was forwarded through the Executive Committee :

"*Science* is taught in most secondary schools. In the primary stage it generally takes the form of elementary biology and nature study. The courses prescribed are mostly theoretical in character, the curriculum being, generally speaking, built around scientific principles rather than around some forms of application of science to everyday life. Hence it is necessary to revise the curriculum and correlate it with life.

Hygiene also finds a place in the school curriculum both in the secondary and the primary stages. The treatment of this subject too suffers from similar defects, *i.e.*, it is mainly theoretical, providing not much scope for the practical application of the principles taught with the help of books to the problems of everday life.

Generally speaking not much *Civics* is taught in the school grades. Whatever little is taught is taught theoretically. The present system does not provide much scope for the practice of principles of good citizenship except within the bounds of the schools and there too in a limited manner. There is very little opportunity for a school student to offer community service.

(*a*) The syllabuses in these subjects should be revised.

(*b*) They should be more practical in outlook providing for practical activities on a community basis.

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* *Vide* Item 10 of the record of the meetings of the Executive Committee.

(c) The curricular work in these subjects should be supplemented by a programme of co-ordinated activities on a community basis aiming at developing a scientific civic outlook.

The actual revision of the syllabuses will have to be left to the different provincial departments of Public Instruction. The details cannot be laid down by the Committee. In connection with the above, however, attention may be drawn to the syllabus prescribed in the Wardha Scheme for Basic Education and also the syllabus adopted recently by the Calcutta Corporation for its primary schools."

7. Some of the members had an opportunity of discussing the programme of work of the Committee with Mr. John Sargent, the Educational Adviser to the Government of India, when he visited Calcutta towards the end of April, 1943. Mr. Sargent expressed himself in general agreement with the views of the Sub-Committee.

8. The Sub-Committee decided to hold a general symposium at the next Session of the Science Congress and "The place of Science in the Indian Educational System" was chosen as the topic. Mr. Sargent agreed to preside over the symposium and Mr. A. N. Basu was asked to open it with a general review of the present situation and suggestions for necessary corrective measures.

RESOLUTIONS ADOPTED BY SECTIONS

Section of Mathematics and Statistics

Separate Sections be established for Mathematics and Statistics with effect from 1946.

Section of Anthropology and Archaeology

(a) This meeting records its great appreciation of the services rendered to the sciences of Archaeology, Ethnology and Anthropology by Sir Aurel Stein, Dr. E. Mackay and Sir Denison Ross and deeply mourns their demise during the year 1942-43.

This resolution be conveyed together with a message of condolence to their respective families.

(b) A Sub-Committee with the following members of the Section of Anthropology and Archaeology be formed to contact the Museum Association organised by the Benares Session of the Oriental Conference so that a meeting of the Association can be held at the next Session of the Science Congress associating all Museum workers interested in the various arts and sciences. This Sub-Committee is to report to the authorities of the Science Congress in time, about the possibilities of holding a meeting and including it in the programme of the next Science Congress.

Members : Mr. P. E. P. Deraniyagala, Colombo.
Mr. J. K. Bose, Calcutta.
Dr. A. Aiyappan, Madras.

(c) This meeting considers it essential for the promotion of anthropoligical and ethnographical studies that there should be founded an Indian Institute of Anthropology which should co-ordinate on an all-India basis not only the studies but should also constitute a central exchange office of duplicate specimens in ethnography in the various museums of India, and promote the publication of scientific studies relating to these branches of science.

A small Sub-Committee of the following two members be appointed for the purpose of laying the basis of such an institution and to report at the next Session of the Science Congress, after consultation and correspondence with whomever they think it is useful to consult.

Dr. C. L. Fabre, Lahore.
Mr. J. K. Bose, Calcutta.

(d) A Committee of civil and military authorities be formed with a view to obtaining for the national collections or to preserving *in situ*, the palaeontological, prehistoric and archaeological materials brought to light by the extensive digging operations undertaken by or for the Fighting Services.

The resolution be forwarded formally to proper authorities with a request to constitute the Committee.

Section of Physiology

The Executive Committee of the Indian Science Congress be asked to appoint a small and representative Committee to consider the present status of physiology in

India and to report on the same. This report is to be forwarded, among others, to the Inter-University Board and Education Department of Government of India.

The Physiology Section suggested the following names for consideration of the Executive Committee :

1. Col. S. L. Bhatia.
2. Dr. B. B. Sarkar.
3. Dr. S. N. Mathur.
4. Dr. S. A. Rahman.
5. Mr. G. K. Ghosh.
6. Dr. W. Burridge.
7. Dr. B. Narayana.
8. Mr. N. M. Basu.
9. Dr. N. K. Basu.
10. Dr. A. L. Mudaliyar.
11. Mr. M. Damodaran.
12. Dr. B. Ahmad.
13. Dr. B. Mukerji.
*14. Dr. Krishna.
*15. Dr. Tilung.
*16. Col. Anand.
*17. Dr. Mundie.
*18. Dr. Panikar.
*19. Prof. Ghosh.

Section of Psychology and Educational Science

(*a*) The Executive Committee of the Science Congress Association set up a Committee to co-operate with the Selection Personnel Directorate of the Army with a view to applying to educational system generally, the results now being obtained by the Directorate in course of psychological testing of military personnel.

A Committee was suggested composed of the following five members with powers to co-opt not more than three other members :

1. Mr. H. P. Maiti.
2. Dr. D. M. Sen.
3. Mr. B. Kuppusawmy.
4. Dr. (Miss) H. K. Cama.
5. Mr. Pars Ram.

(*b*) The Section places on record its protest that the recommendation of the Sectional Committee in the matter of appointment of Sectional Recorder for 1945 has been ignored by the Executive Committee.

Sections of Engineering and Metallurgy and Chemistry at a Joint Meeting

This joint meeting of the Sections of Engineering and Metallurgy and of Chemistry recommend that in view of the vital importance of the Electro-chemical Industries an Institute for Electro-chemical and Electro-thermal Research be established.

10. RULES AND REGULATIONS.

RULES.

1. The name of the Association shall be the Indian Science Congress Association, and its objects shall be the advancement of Science in India by the annual holding of a Congress and the doing of all such things as are incidental or conducive to the above object, including—
   (*a*) the holding and management of funds and property;
   (*b*) the acquisition of rights and privileges necessary or convenient for the object of the Association;
   (*c*) the management, development, improvement, disposal and sale of all and any parts of the property of the Association.

2. The Association shall consist of Ordinary Members, Sustaining Members, Benefactors, Honorary Members and Session Members.

3. Ordinary Members of the Association shall have the right to contribute papers for reading at the Session of the Congress, to receive free of charge all publications issued by the Association, and to fill any office in the Association on being duly elected thereto.

* Initials not known and their names and addresses could not be traced in members' list.

4. The annual subscription of Ordinary Members shall be Rs. 12. The subscription shall become due on the 1st February of each year and shall only be effective as a payment for Ordinary Membership subscription if received before the 15th July of the year.

5. Any Ordinary Member may compound for the payment of all future annual subscriptions by the payment in a single sum of Rs. 150.

6. Any Ordinary Member agreeing to pay one additional subscription (Rs. 12) during his period of membership shall be called Sustaining Member.

7. Any person paying a lump sum of Rs. 500 or more or any institution paying a lump sum of Rs. 1,000 or more shall be a Benefactor of the Association, subject to the approval of the Executive Committee. Benefactors shall have all rights and privileges of Ordinary Members during their lifetime.

An institutional Benefactor shall have the right to nominate one person as Ordinary Member of the Association.

8. Honorary Members shall have all the rights and privileges of Ordinary Members.

Honorary Members, the number of whom shall be limited to fifteen at any one time, shall be persons eminent for their contributions to Science or persons who have rendered conspicuous services to the cause of Science in India.

Honorary Members shall be unanimously nominated by the Executive Committee subject to confirmation by the Council and the General Committee at its annual meeting. Not more than one Honorary Member shall be elected in any year.

9. There shall be three classes of Session Members :—

(*a*) Full Session Members—subscription Rs. 12 per Session.
(*b*) Associate Session Members—subscription Rs. 5 per Session.
(*c*) Student Session Members—subscription Rs. 2 per Session.

10. Full Session Members shall have the right to contribute papers for reading at the Session of the Congress, and to receive free of charge all publications issued by the Association relating to the Session of the Congress of which they are Members.

Associate and Student Session Members shall have the right to submit papers for reading at the Session of the Congress of which they are Members, provided such papers be communicated through an Ordinary or an Honorary Member of the Association.

A Student Member shall before admission be duly certified by the head of his Institution to be a *bona fide* student.

Associate and Student Session Members shall receive free of cost the Abstracts of Papers contributed for the Session of which they are members.

11. The official year of the Association shall commence from the 1st of February.

12. There shall be Officers of the Association consisting of the Members of the Executive Committee and Presidents and Recorders of Sections.

13. Only Ordinary and Honorary Members shall hold office in the Association.

14. The term of office of all Officers of the Association except the President shall commence from the beginning of the official year and shall extend until the assumption of office by their successors, appointed in accordance with the provisions of these Rules. The President shall assume office on the opening day of the Annual Congress following the one at which he is appointed, and shall continue to hold office until the assumption of office by his successor.

15. There shall be an Executive Committee which shall carry on the administrative work of the Association and submit such questions as it thinks desirable to a General Committee at its Annual Meeting during the Session of the Congress or at a Special Meeting of which due notice shall have been given.

16. The Executive Committee shall consist of the President, the President-elect for the following year, the two General Secretaries, the Treasurer and seven Members, Ordinary or Honorary, elected by the General Committee. For the purpose of this election any Ordinary or Honorary Member may propose the name of an Ordinary or an Honorary Member for election to the Executive Committee. Such proposal must be seconded by another Ordinary or Honorary Member and must reach the General Secretary before the 15th September. The Executive Committee shall circulate the names, together with such other names, not exceeding three, as it may suggest, to all Ordinary and Honorary Members for election by ballot. The ballot papers will be scrutinized by the President or his nominee and the General Secretaries, and the results of the ballot will be announced at the meeting of the General Committee.

The Executive Committee shall co-opt as Members at least one and not more than two Local Secretaries for the ensuing Session of the Congress.

17. The Executive Committee shall have full power to transact all business in cases of emergency, notwithstanding any limitations hereinafter laid down, and

to deal with all matters not otherwise provided for in these Rules, including the making of such Regulations as may appear conducive to the good administration of the Association and the attainment of its object; provided always that such Regulations be not inconsistent with anything contained in these Rules, that they be reported for the information of the next meeting of the General Committee, and that they be subject to rescission or alteration by the Executive Committee or by any meeting of the General Committee.

18. There shall be a General Committee which shall consist of all Ordinary and Honorary Members of the Association.

19. The General Committee shall meet at least once during each Session of the Congress, preferably, in the middle of the Session.

20. There shall be a Council which shall consist of all Members of the Executive Committee, and all such Ordinary and Honorary Members of the Association as have held office as President, General Secretatry, Treasurer, or Managing Secretary of the Association, the Sectional Presidents for the ensuing Session, and in addition seven Members of the Association, Ordinary or Honorary, elected by the General Committee. For the purpose of this election any Ordinary or Honorary Member may propose the name of an Ordinary or an Honorary Member for election to the Council. Such proposal must be seconded by another Ordinary or Honorary Member and must reach the General Secretary before the 15th September. The Executive Committee shall circulate these names, together with such other names, not exceeding three, as it may suggest, to all Ordinary and Honorary Members for election by ballot. The ballot papers will be scrutinized by the President or his nominee and the General Secretaries, and the results of the ballot will be announced at the meeting of the General Committee.

21. The function of the Council shall be to act as a body of advisers to be consulted by the Executive Committee on important questions of policy or scientific import.

22. There shall be a President who shall be nominated by the Executive Committee and whose nomination shall be submitted to the General Committee at its Annual Meeting during the Session of the Congress for confirmation.

23. There shall be two General Secretaries (one of whom shall be resident in Calcutta) who shall be nominated by the Executive Committee and whose nomination shall be submitted to the General Committee at its Annual Meeting during the Session of the Congress for confirmation.

24. There shall be a Treasurer who shall be nominated by the Executive Committee and whose nomination shall be submitted for confirmation to the General Committee at its Annual Meeting during the Session of the Congress.

25. The term of office of each General Secretary and of the Treasurer shall be for a period of five years following the confirmation of the appointment of any one of them, and each of them shall be eligible for re-appointment.

26. In the event of a vacancy amongst the General Secretaries and the Treasurer occurring between two Sessions of the Congress the Executive Committee shall have power to appoint a General Secretary or the Treasurer for the period up to the termination of the next Session of the Congress.

27. There shall be a Local Secretary or Local Secretaries for each Session of the Congress who shall be appointed by the Executive Committee.

28. There shall be a Local Committee for each Session of the Congress which shall be appointed by the Executive Committee.

29. The Local Secretary, or Secretaries, and the Local Committee shall jointly, on behalf of and in consultation with the Executive Committee, make all necessary arrangements for the holding of the Session of the Congress.

30. For the purpose of scientific deliberations during the Session of the Congress there shall be such Sections corresponding to different branches of science as may from time to time be constituted by the General Committee on the recommendation of the Executive Committee. It shall be competent for any Section after the first day's meeting to hold its scientific meetings in sub-sections for the purpose of dealing separately with different groups of papers submitted to that Section. A separate chairman may be appointed by the Sectional President in consultation with the Sectional Committee to preside over each sub-section.

31. There shall be in each Section a President and a Recorder who shall be appointed by the Executive Committee. In addition there shall be a Sectional Correspondent and a Local Sectional Secretary who shall be appointed by the Executive Committee.

32. In each Section there shall be Sectional Officers, namely, a President, a Recorder, a Sectional Correspondent, and a Local Sectional Secretary. The President and the Recorder shall be the chief executive officers of the Section. They shall have power to act on behalf of the Sectional Committee in any matter of

urgency which cannot be brought before the Sectional Committee for consideration, and they shall report such action to the Sectional Committee at its next meeting.

The work of each Section shall be conducted by a Sectional Committee which shall be constituted as follows :—

(*a*) Sectional Officers.

(*b*) All Ordinary and Honorary Members of the Association who have been Presidents or Recorders of the Section.

(*c*) Two Members of the Association, Ordinary or Honorary, elected by the General Committee at its Annual Meeting during the Session of the Congress.

The Sectional President shall preside over all meetings of the Section and of the Sectional Committee. He shall be the convener of the meetings of the Sectional Committee. His ruling shall be final on all points of order that may arise.

The Sectional Recorder shall act as the Secretary of the Sectional Committee, and shall maintain a proper record of the proceedings of the Sectional Committee and of the Section in a book provided for the purpose. He shall be responsible for the punctual transmission to the General Secretary of the recommendations adopted by the Sectional Committee, and of resolutions adopted by the Section.

The Sectional Correspondent shall be resident at the headquarters of the Association, and shall be responsible for preparing for the press the material relating to his Section, according to the instructions of the Sectional President.

The Local Sectional Secretary shall be resident in the locality where the Annual Session is held, and shall be responsible for all local arrangements for the work of his Section, and for arranging the Sectional excursions in consultation with the Local Secretaries.

33. The Sectional Committee shall meet on the opening day of each Session of the Congress, and daily thereafter during the Session before the meeting of the Session unless otherwise determined at a meeting of the Sectional Committee.

In the absence of the Sectional President from any of its meetings the most senior member of the Sectional Committee present shall take the chair.

In their meeting on the opening day they shall

(*a*) nominate a Sectional President and a Sectional Recorder for the ensuing year for the consideration of the Executive Committee;

(*b*) determine the detailed arrangements for the Sectional meetings;

(*c*) select the papers to be read and discussed;

and in their meetings during the Session they shall also

(*d*) nominate a Sectional Correspondent and a Local Sectional Secretary for the ensuing year for the consideration of the Executive Committee;

(*e*) determine the contents of the Sectional records in the Proceedings in accordance with Rule 34(*c*);

(*f*) consider means of improving the scientific work of the Section, and make suggestions to the Executive Committee whenever considered necessary;

(*g*) select topics for discussions at the next Session of the Congress and make necessary arrangements (*i*) through the President of the Section concerned for discussions within a Section, and (*ii*) through the Sectional President who has initiated the proposal for a discussion in which more than one Section will participate.

34(*a*) All papers submitted for reading at the next Session of the Congress shall be forwarded to the General Secretary so as to reach him not later than September 15th of the calendar year preceding the Session of the Congress at which the papers are intended to be read, provided that this date may be changed by the Executive Committee for special reasons.

(*b*) Any paper submitted for reading at the Session of the Congress shall be accompanied by an abstract in triplicate.

(*c*) All papers submitted for reading at a Session of the Congress shall be checked by the Sectional Correspondent concerned or by such person or persons appointed by the General Secretary. The papers together with a copy each of the abstracts shall then be sent to the Sectional President concerned for refereeing and acceptance. Decisions with regard to acceptance or rejection of any paper shall be final and all reports confidential.

(*d*) No paper published elsewhere shall be accepted.

(*e*) Only abstracts of the papers received by the General Secretary before September 15th in accordance with Rule 34 (*a*), (*b*) and (*c*) shall be printed in Part III of the Proceedings. In exceptional circumstances, abstracts of papers received after that date and read before the Section, if specially recommended by the Sectional Committee, may be printed in Part IV.

35. The Proceedings of the Indian Science Congress Association shall be published in one volume in four separate parts, as follows :—

I. To contain the list of officers, the Proceedings of the opening meeting (except the General Presidential Address) and all official matters.

II. To contain the Presidential Addresses. To be distributed to those present at the meeting after the addresses have been delivered, and to absent Ordinary, Honorary and Full Session Members by post after the meeting.

III. To contain the abstracts of papers to be read before the Sections which are received before September 15th in accordance with Rule 34 (*a*). No abstracts shall be included in this volume from authors who have not enrolled themselves as Members of the Association. To be distributed in advance of the meeting to all Members of the Association.

IV. To contain the discussions, late abstracts accepted in accordance with Rule 34 (*c*), the list of members and the index.

36. The following procedure shall be observed for the making of any addition to or alteration in the Rules of the Association :—

(i) Proposals for additions to and alterations in the existing Rules may be placed at any time before the General Committee by the Executive Committee.

(ii) (*a*) Proposals for additions to and alterations in the existing Rules by any Ordinary or Honorary Member of the Association shall be sent to one of the General Secretaries so as to reach him two full months before the meeting of the General Committee in which they are to be moved.

(*b*) One of the General Secretaries shall circulate such proposals to all Ordinary and Honorary Members of the Association at least one full month before the meeting of the General Committee.

(*c*) Any amendments to the proposals shall be sent by any Ordinary or Honorary Member of the Association to one of the General Secretaries so as to reach him at least a fortnight before the meeting of the General Committee.

(*d*) The proposals together with any amendments shall be brought up before the meeting of the General Committee at its Annual Meeting during the Session of the Congress together with any remarks of the Executive Committee and declared carried if accepted by a two-thirds majority of the constituent Members present and voting at the meeting.

(*Adopted* the 5th January, 1931. *Revised* the 5th January, 1935, the 6th January, 1936, the 5th January, 1937, the 8th January, 1939, the 6th January, 1940, the 5th January, 1942 and the 4th January, 1943.)

REGULATIONS.

I. Sectional Officers

(1) The President delivers a Presidential Address of which ordinarily the cost of printing 16 pages of the Proceedings in its usual form shall be borne by the Indian Science Congress Association and any author exceeding the limit shall bear the extra cost, provided that in no case the Presidential Addresses shall exceed 25 pages. The time available for delivery of the Presidential Address shall usually not exceed 45 minutes. The manuscript of the address, ready for the press, should be received by the General Secretary before October 15th of the calendar year preceding the Session of the Congress at which the address will be delivered, provided that this date may be changed by the Executive Committee for special reasons. It should be accompanied by 12 copies of a short popular summary (about 500 words) for issue to the lay press. The time and date of the delivery of the President's Address will be communicated before the meeting of the Congress. No two Presidential Addresses will be delivered at the same time.

(2) The President shall be entitled to receive 30 copies of his address without charge, and additional copies at the cost of reproduction.

(3) Railway fares, postage, clerical or other expenses incurred by the Sectional Presidents will not be paid by the Association.

(4) The following procedure is adopted for the collection of papers for the Sections :—

About the middle of April a number of copies of a printed circular will be forwarded to the President of each Section who may arrange to send these to workers in that branch of science with which his Section is concerned, requesting them to contribute papers for reading before the next meeting of the Congress.

The circular will contain a clause inviting such workers as are not yet Ordinary Members of the Association to join as such. Particular note should be taken of the fact that no new Ordinary Members are enrolled after the 15th July of the year.

In the case of joint papers, each author must be a Member of some category.

(5) The President referees, either in person or by proxy, the papers received for reading before his Section in accordance with Rule 34.

Abstracts should be limited, except in very special cases, to about 200 words. Long abstracts should be reduced by the President. References to literature in abstracts should be avoided as far as possible and when given should conform to the system of abbreviations used by the Association.

The contents of all abstracts should be carefully checked by the Sectional Correspondent concerned or by such person or persons appointed by the General Secretary, and the abstracts shall then be sent to the Sectional President for his final scrutiny and approval.

Joint discussions on related papers may be held. Authors of papers should be informed of the time allotted by the President to the reading of their papers. An author contributing more than one paper should be asked to specify which of them he would prefer to read at the meting.

(6) The President, in consultation with the Local Sectional Secretary, shall make arrangements for such local Sectional excursions as seem desirable. Due notice shall be given to the General Secretaries of all such arrangements.

(7) The President and the Recorder should, in consultation with other members of the Sectional Committee, make proposals to the General Secretary regarding the programme of the Section. Such proposals should reach the General Secretary not later than the 1st November, so as to enable the necessary details to be entered in the programme. General discussions on questions of importance, held either by a single Section or jointly by two or more Sections, should be encouraged.

The Sectional Presidents concerned shall communicate to the General Secretary before the end of July the titles of such discussions, the names of the speakers and such further information as may be considered necessary.

The Papers, together with three copies of abstracts, to be read by the contributors at a discussion shall be sent to the General Secretary on or before the 15th September of the preceding calendar year by the Sectional President concerned.

The materials relating to a discussion, in a form ready for the press, shall be communicated to the General Secretary within a month from the date on which the discussion takes place; the material not received by the General Secretary within this period shall not be published.

The President and the Recorder of the Section arranging a discussion shall carry out the necessary correspondence throughout the year during which they hold office.

(8) Early in November copies of a printed form will be issued to Presidents of Sections for circulation to members of the Sectional Committees requesting them to nominate a President and a Recorder for the ensuing meeting for consideration by the Sectional Committee. Such proposals shall be accompanied by a statement of qualifications of the nominees for the office and their willingness to accept the same if elected thereto.

During the first week of December, the President of each Section shall circulate all such proposals received by him, together with the statements of qualifications, to the members of the Sectional Committee and request them to nominate by ballot one member for each office from among the list circulated, the ballot papers being received by him up to the 20th December.

At the first meeting of the Sectional Committee held on the opening day, the ballot papers shall be opened and scrutinized as the Chairman shall direct and the result communicated to the Executive Committee for consideration, together with a complete record of the Proceedings in this connection.

(9) The duties of the Sectional Correspondent and of the Local Sectional Secretary are given in Rules 32 and 34(*c*).

(10) All persons entitled to be members of the Sectional Committee should enrol themselves without delay as Ordinary Members if not already so enrolled and should inform the General Secretary of the payment of their subscription when accepting the appointment.

(11) The General Secretary should be consulted whenever any question arises not dealt with in these regulations.

II. Local Arrangements

In accordance with the Rules of the Association, the Local Secretaries and the Local Committee shall jointly, on behalf of and in consultation with the Executive Committee, make all necessary arrangements for holding the Session of the Congress.

The following arrangements have to be made :—

A. Accommodation for the Scientific Meetings

(1) A large hall should be available for (*a*) the President's address on the opening day, and (*b*) for the evening lectures. Both (*a*) and (*b*) are open to the public free of charge. A projection lantern with an operator should be available in this room, and it is a great advantage if loud speakers can be installed.

(2) Rooms for the meetings of the different Sections of the Congress should be provided and suitably furnished. An epidiascope with an operator should be provided in each sectional room. All the rooms should be as far as possible in close proximity. The following are the Sections of the Congress :—

Mathematics and Statistics, Physics, Chemistry, Geology and Geography, Botany, Zoology and Entomology, Anthropology and Archaeology, Medical and Veterinary Sciences, Agricultural Sciences, Physiology, Psychology and Education Science, and Engineering and Metallurgy.

(3) A Reception room should be provided in which members can get information, write letters, etc. The Local Secretaries' Office should be as near as possible to this room. An arrangement should be made with the Postmaster-General to have a temporary Post Office in this room and for all letters addressed to members c/o The Indian Science Congress to be delivered here. The Indian Science Congress Post Office should be situated as near as possible to the Reception room.

(4) A room near the Reception room should be set apart for the General Secretaries' Office, which will be opened therein from the 31st December.

(5) Provision should be made for lunch in European and Indian styles at moderate charges near the Reception room.

B. Accommodation for Visiting Members

The Local Secretaries should send out, not later than the end of November, a printed circular to all members enrolled, asking them if they desire that accommodation should be arranged for them. It is desirable, as far as possible, to provide private hospitality for the President, Sectional Presidents and Officers of the Congress. In this circular information should be given regarding the types of accommodation available, with the charges, and the nature of the climate during the Session. The Local Secretaries will receive periodically from the General Secretary list of members enrolled at headquarters.

C. Programme of the Meeting

(1) (*a*) The Sections of the Congress meet daily in the morning generally from 9-30 A.M.

(*b*) Presidential Addresses of the Sections shall commence from 9-30 A.M.

(*c*) There should be no afternoon Presidential Addresses of the Sections.

(*d*) Symposia or joint discussions will be held either in the morning, or from 2 P.M.

(2) Public lectures are arranged by the Executive Committee, and are given at 6 P.M. or 6-30 P.M.

(3) A printed guide with a map of the locality in which the Congress is held should be prepared for distribution to members on the opening day. Only Ordinary, Honorary and Full Session Members are entitled to the Guide Book free of cost. A small charge not exceeding Re. 1 (to be fixed by the Local Committee) may be made to other members desiring to have a copy. The Guide Book should contain a summary of information concerning the scientific and educational activities and a short history of the locality, in addition to general information likely to be of use to visitors.

(4) Arrangements should be made for giving due publicity to the activities of the Congress, both before and during the meeting.

(5) A list of members with their local addresses where known should be printed and distributed on the opening day. A supplementary list should be typed and posted in the Reception room and maintained up to date. The Local Secretaries shall arrange for this.

(6) A provisional programme of social engagements should be drawn up by the Local Secretaries and sent to the General Secretary by the 25th November. It is essential that this be sent in time, as it has to be printed and distributed with the abstracts by the first week of December.

The General Secretary will make arrangements for printing the programme drafted as above and distributing these to members enrolled at the time of the distribution of the abstracts.

The final programme shall be printed locally by the Local Committee in time for the opening of the Session.

D. *General*

(1) Numbered badges for members of the Congress will be sent by the General Secretary to the Local Secretaries for distribution on the opening day of the meeting. The badges should bear numbers corresponding to the enrolment numbers. There should be additional badges for Officers.

(2) Members of the Local Reception Committee who have made substantial contributions to the funds of the Local Committee may be given complimentary tickets to attend the meetings.

(3) An audited copy of the accounts of the Local Committee should be sent to the General Secretary not later than the 30th April, following the Session, for inclusion in the Proceedings of the Session. It is desirable that the Local Committee should contribute any surplus to the reserve fund of the Association.

(4) Twelve copies each of all local publications connected with the Congress (Guide Book, final programme, notices, cards, etc.) should be sent to the office of the Association for record at the conclusion of the meeting.

(5) Applications for membership will ordinarily be dealt with by the General Secretary at the Office of the Association up to the 15th December. After that date applications for membership will be forwarded to the Local Secretaries, who will open a separate account for the sale of membership tickets. The amount thus realized, together with unsold tickets, should be forwarded to the General Secretary immediately after the close of the Congress.

III. Financial

(1) The accounts of the Association shall be audited once a year and the books closed on the 30th November each year for this purpose.

(2) The audited accounts shall be placed before the General Committee at the Annual Meeting with the observations, if any, of the Executive Committee.

(3) Sanction for all payments for amounts exceeding Rs. 100 shall be obtained from the Finance Committee which shall consist of the General Secretaries, the Treasurer, and one Ordinary or Honorary Member resident in Calcutta who shall be nominated by the Executive Committee.

(4) Amounts received on account of Life Membership Subscription shall be credited to the Reserve Fund of the Association.

IV. Election by the Executive Committee

(1) A letter shall be issued asking for nominations giving a last date therefor.

(2) The proposer should ascertain whether the person he proposes is desirous of serving in that particular capacity.

(3) After the nominations have been received the names should be circulated in a ballot paper and the date for return should be fixed two weeks after the ballot paper is sent out.

V. Nomination of General President

(1) The General Secretary shall invite nominations for the office of General President of the Association, two years in advance, by a circular letter to the members of the Council, not later than the 15th of October. Such circular shall include a list of the General Presidents of the past 15 years, and the branches of science in which they had specialized.

Nominations shall reach the General Secretary not later than the 15th of November.

(2) The General Secretary shall circulate the nominations received to the members of the Executive Committee for expression of opinion on or before the 30th November. Such opinions shall reach the General Secretary not later than the 15th of December.

(3) The nominations, together with the views of members thereon, shall be placed for decision before a meeting of the Executive Committee to be held on the day previous to the commencement of the Session of the Congress.

(*Adopted* the 5th January, 1937. *Revised* the 8th January, 1939, the 6th January, 1940, the 6th January, 1941, the 5th January, 1942 and the 4th January, 1943.)

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11. STATEMENT OF ACCOUNTS OF THE ASSOCIATION.

Receipts and Payments Account for the year ending 30th November, 1943.

RECEIPTS

	Rs.	A.	P.	Rs.	A.	P.
To Balance as on 1st Dec., 1942 :—						
Reserve Fund						
Investments—						
4% Loan 1960-70 Face Value of Rs. 5,000/1 at cost ...	5,918	9	4			
3% G. P. Notes Face Value of Rs. 1,000/- at cost ...	945	3	0			
With Imperial Bank of India in Current A/c.	2,045	1	6			
Imprest Cash (as certified) ...	115	0	0			
				9,023	13	10
,, Subscriptions—						
Ordinary & Session Members	11,646	2	6			
In Advance	24	0	0			
Life Members	750	0	0			
				12,420	2	6
,, Interest on Investments ...	...			337	12	0
,, Sale of Publications ...	...			885	11	6
,, Contributions	...			7,445	7	6
,, Miscellaneous Receipts—						
Bank Charges	16	8	6			
Printing	598	14	6			
Postage	76	9	0			
				692	0	0
Total ...				Rs. 30,804	15	4

PAYMENTS

	Rs.	A.	P.	Rs.	A.	P.
By Printing	...			14,510	4	3
,, Postage and Telegrams ...	...			1,160	15	6
,, Salaries and Allowances ...	...			2,986	0	0
,, Audit Fees	...			50	0	0
,, Grant to Sub-Committee on 'Science and its Social Relations'	...			50	0	0
,, Bank Charges	...			52	5	6
,, Contingency :						
Stationery	218	13	9			
Local Conveyance	46	12	9			
Badges	100	0	0			
Miscellaneous	29	12	6			
				395	7	0
,, Balance—						
Reserve Fund						
Investments :—						
4% Loan 1960-70 Face Value of Rs. 5,000/- at cost ...	5,918	9	4			
3% G. P. Notes Face Value of Rs. 1,000/- at cost ...	945	3	0			
With Imperial Bank of India	3,276	6	6			
With Imperial Bank of India in Current A/c.	1,344	12	3			
Imprest Cash (as certified) ...	115	0	0			
				11,599	15	1
Total ...				Rs. 30,804	15	4

Examined with the books and vouchers and found in accordance therewith.

6, Church Lane,
Calcutta, December 23, 1943.

RAY & RAY,
Chartered Accountants
Registered Accountants } *Auditors.*

J. N. MUKHERJEE
Treasurer.

Proceedings of the Thirtyfirst Indian Science Congress
Delhi, 1944

PART II—PRESIDENTIAL ADDRESSES

CONTENTS

Thirtyfirst Indian Science Congress

DELHI, 1944

PRESIDENTIAL ADDRESS

CONGRESS PRESIDENT: PROFESSOR S. N. BOSE

THE CLASSICAL DETERMINISM AND THE QUANTUM THEORY

(Delivered on Jan. 3, 1944)

I wish to express sincere thanks for the great honour you have done me. The Presidentship of the Science Congress is a great distinction, and I confess, I have my own misgivings about the wisdom of your choice. Your first decision had raised high hopes. Many of us expected that a deliberate programme of the future scientific activities of the country would probably be a feature of the opening speech of this Congress. Pandit Jawaharlal had studied the needs of the country. Many of our front-rank scientists and industrialists had met under his leadership, not long ago, and given to questions of future reconstruction much time and anxious thought. The results of this deliberation would have been invaluable at the present moment. My regret is keen that chance has deprived us of the benefits of a sustained and careful study of the problems of the day. I would have liked to present here the results, if they were available. Unfortunately they are not, as most of the reports are inaccessible to me.

One of your former Presidents had remarked that "a scientist is apt to become a man that knows more and more about less and less, so that his opinion upon subjects outside his field of special study is not necessarily of special value". I realise the wisdom of this warning and hope to have your indulgence, if I seem to be more at home with doubts and criticisms than with useful knowledge.

I would like to present before you certain aspects of modern physics and draw your attention to the profound changes in the principle of scientific explanation of natural phenomena brought about by the quantum theory. The last fifty years record remarkable discoveries. I need only mention the electron and the neutron, X-rays and Radio-activity to remind you of the increase of our knowledge. Our equipment has gained in power range and accuracy. We possess powerful telescopes to scan the furthest corners of the universe, also precise and delicate instruments to probe into the interior of the atoms and molecules. The alchemists' dream of transmutation has become a reality. Atoms are now disintegrated and synthesised. X-ray reveals invisible worlds and wireless links up the furthest ends of the earth with possibility of immediate intercommunication. These discoveries have their repercussions in the realm of ideas. Fifty years ago the belief in causality and determination was absolute. To-day physicists have gained knowledge but lost their faith. To understand properly the significance of such a profound change it will be necessary to discuss briefly how it all came about. Classical physics had begun with the study of astronomy. With his laws of gravitation and his dynamics Newton had explained planetary motion. Subsequent study has shown astronomical prediction to be possible and sure. Physicists had taken the equations of celestial mechanics as their model of a universal law. The atomic theory had in the mean time gained

universal acceptance ; since matter had resolved into a conglomeration of particles, the ideal scheme was to explain all phenomena in terms of their motions and interactions. It was only necessary to set up a proper set of equations, and to take account of all possible mutual interactions. If the mass, position, and velocity of all the particles were known at any instant, these equations would theoretically enable the physicist to predict the position and motion of every particle at any other subsequent moment.

The phenomena of light did not at first fit into this simple scheme. To regard it as a stream of particles was impossible due to the discovery of interference. Accordingly the wave theory of light was originated by Huyghens and perfected by Maxwell. With the discovery of the electron as a universal constituent of matter, the electromagnetic theory of Maxwell was converted into an electronic theory by Lorentz. To the dynamical laws were added the electromagnetic equations and the two together apparently gave an exact and ideal formulation of the laws of causality. In the forces of interaction henceforth, were to be included not only the gravitational forces but also those interactions which depended on the charge and the motion of the particles. These interactions were brought about by influences which spread out as waves with the velocity of light. They superimposed, interfered and constituted the field of force in the neighbourhood of the particles, modified their motion and were in turn modified by them. The motions of all particles throughout the universe were thus interlocked. These out-going influences also constituted light, invisible radiation, X-rays and wireless waves. Thus a set of universal laws was supposed to have been discovered and we had only to apply them suitably to find explanations of all conceivable natural phenomena. In physical science we do not however always proceed in the above way and turn to the "microscopic" equations whenever we have to explain events. We often study materials *en masse*, consisting of an enormous number of corpuscles, and we use either the principle of the conservation of energy or the laws of thermodynamics to explain their behaviour. These laws were however regarded either as simple consequences of the fundamental equations or as statistical laws derivable from them by a suitable averaging. Though in the latter cases we talk about probabilities and fluctuations, it was more or less a matter of faith to maintain that if it were possible for us to obtain all the necessary data by delicate observations, universal laws would enable us to follow each individual molecule in this intricate labyrinth and we should find in each case an exact fulfilment of the laws and agreement with observation. The above in brief forms an expression of faith of a classical physicist. We see that it involves as necessary consequences, belief in continuity, in the possibility of space-time description of all changes and in the existence of universal laws independent of observers which inexorably determine the course of future events and the fate of the material world for all times.

A few remarks about the general equations will perhaps enable us to follow better the criticisms that have been levelled against the system. The structure of the mechanical equations of particles is different from the field-equations of Maxwell and Lorentz. The principles of conservation of energy and momentum were first discovered as consequences of the mechanical equations. Mass and velocity of the corpuscle furnish means to measure its momentum, and its energy, if we leave aside the potential energy which resides in the field. To maintain the integrity of the principle of conservation, the field must also be considered capable of possessing energy and momentum, which however, being associated with wave-motion, must spread out in all directions with the waves. The transfer

of energy from the field to the particles must thus be a continuous process, whereby, a finite change should come about only in a finite interval and the process should theoretically be capable of an exact description in space and time.

Physics being essentially concerned with relations between quantities, these should all be capable of exact measurement. We measure always intervals of time or inter-distance between points, hence the specification of the reference frame is just as important as the units of measure. Newton had not analysed closely the conception of mass and time. This vagueness persisted in the dynamical equations for the particles. The field-equations which form the basis of the wave-theory of light have a different origin. With the discovery of the principle of the least action, a common derivation of both has been attempted. But a difference in the choice of reference frame in the two apparently subsisted. The wave-equations assumed a fixed ether whereas the material laws contemplated a Galilean inertial-frame. An immediate deduction from this distinction was the possibility of measuring the relative velocity of the observer with reference to ether. The experiment of Michelson and Morley showed it to be unrealisable in practice and formed the starting point of the celebrated Relativity Theory. Einstein had subjected the conception of time-measurement to a searching examination and showed the impossibility of conceiving a time independent of an observer, or an absolute simultaneity of events happening at two different places. The same space-time reference should be chosen for the dynamical equations as well as the equations of the field, this being supplied by the observer. In spite of this apparent limitation Einstein demonstrated the possibility of formulation of natural laws independent of all axes of reference and pointed out that the necessary auxiliaries existed already in the invariant theory and the tensor Calculus of mathematicians. In spite of its apparently revolutionary character, the theory of relativity upheld the ideal of causality and determinism. Einstein himself has continued to seek with great earnestness a unifying field theory which will combine gravitation and electromagnetism and render unnecessary a separate formulation of the dynamical equations. No such theory as yet exists.

II

The development of the quantum theory has raised fundamental issues. Facts have been discovered which demonstrate the breakdown of the fundamental equations which justified our belief in determinism. A critical examination of the way in which physical measurements are made has shown the impossibility of measuring accurately all the quantities necessary for a space-time description of the motion of the corpuscles.

Experiments reveal either the corpuscular or the wave nature for the photon or the electron according to the circumstances of the case, and present us with an apparently impossible task of fusing two contradictory characters into one sensible image. The only solution suggested has been a renunciation of space-time representation of atomic phenomena and with it our belief in causality and determinism.

Let me briefly recapitulate the facts. In 1900 Planck discovered the quantum of action while studying the conditions of equilibrium between matter and the radiation field. Apparently interchange of energy took place in discrete units whose magnitude depended on 'h' and the frequency of the radiation emitted or absorbed by matter. Photo-electric emission had similar disquieting features. Einstein therefore suggested a discrete structure of the radiation field in which energy existed in quanta

instead of being continuously distributed in space as required by the wave-theory. This light-quantum however is not the old light-corpuscle of Newton. The rich experimental materials supporting the wave-theory preclude that possibility altogether. Moreover the fundamental relation, $E=h\nu$, and $p=hk$, connecting energy and momentum of the photon with the frequency ν and the vector wave number k, makes a direct reference to idealised plane wave so foreign to the old idea of a corpuscle. Soon afterwards Bohr postulated the existence of radiationless stationary states of atoms and showed how it led to a simple explanation of the atomic spectra. The extreme simplicity of the proposed structure and its striking success in correlating a multitude of experimental facts at once revealed the inadequacy of the ordinary laws of mechanics and electro-dynamics in explaining the remarkable stability of the atoms.

The new ideas found application in different branches of physics. Discontinuous quantum processes furnished solutions to many puzzles. Suitably modified, the theory furnished a reasonable explanation of the periodic classification of elements and thermal behaviour of substances at low temperature. There was however one striking feature. It was apparently impossible to characterise the details of the actual transition processes from one stationary state to another, that is, to visualise it as a continuous sequence of changes determined by any law as yet undiscovered. It became clear that the dynamical laws as well as the laws of electromagnetism failed to account for atomic processes. New laws had to be sought out compatible with the quantum theory capable at the same time of explaining the rich experimental materials of classical physics. Bohr and his pupils utilised for a time a correspondence principle, guessing correct laws for atomic processes from analogy with the results of the classical theory. In every case these appeared as statistical laws concerned with the probabilities of transition between the various atomic states. Einstein tackled the problem of the equilibrium of matter and radiation on the basis of certain hypotheses regarding the probabilities of transition between the various states by absorption and emission. A derivation of the Planck Law was obtained by Bose by a suitable modification of the methods of classical statistics. Heisenberg finally arrived at a satisfactory solution and discovered his matrix-mechanics and a general method for all atomic problems. Dirac and Schrödinger also published simultaneously their independent solutions. Though clothed in apparently dissimilar mathematical symbols, the three theories gave identical results and have now come to be looked upon as different formalisms expressing the same statistical laws.

I have mentioned that the photon gave a simple explanation of many of the properties of radiation and thereby presented its corpuscular aspect while the well-known properties of interference and superposibility brought out its wave character. That the same dual nature may exist in all material corpuscles was first imagined by De Broglie. His phase-waves found quick experimental verification, and raised a similar problem of the real nature of the corpuscle. The formulation of wave-mechanics by Schrödinger, once raised a hope that by a radical modification of our usual ideas about the corpuscle it might be possible to re-establish the law of causality and classical determinism. Subsequent developments have shown such hopes to be illusory. His waves are mathematical fictions utilising the multidimensional representation of a phase-space and are just as incapable of explaining the individuality of the electron, as the photon is incapable of explaining the superposibility of the field. The true meaning of his equations appears in their statistical interpretation.

III

The adherents of the quantum theory interpret the equations in a peculiar way. They maintain that these equations make statements about the behaviour of a simple atom and nothing more than a calculation of the probabilities of transition between its different states is ever possible. There is nothing incomprehensible about such a statistical law even if it relates to the behaviour of a single particle. But a follower of determinism will interpret such statements as betraying imperfect knowledge, either of the attendant circumstances or of the elementary laws. We may record the throws when a certain die is cast a large number of times and arrive at a statistical law which will tell us how many times out of a thousand it will fall on a certain side. But if we can take into account the exact location of its centre of gravity, all the circumstances of the throw, the initial velocity, the resistance of the table and the air and every other peculiarity that may affect it, there can be no question of chance, because each time we can reckon where the die will stop and know in what position it will rest. It is the assertion of the impossibility of even conceiving such elementary determining laws for the atomic system that is disconcerting to the classical physicist.

Von Neumann has analysed the statistical interpretation of the quantum mechanical laws and claims to have demonstrated that the results of the quantum theory cannot be regarded as obtainable from exact causal laws by a process of averaging. He asserts definitely that a causal explanation of quantum mechanics is not possible without an essential modification or sacrifice of some parts of the existing theory.

Bohr has recently analysed the situation and asserted that we cannot hope any future development of the theory will ever allow a return to a description of the atomic phenomena more conformable to the ideal of causality. He points out the importance of the searching analysis of the theory of observation made by Heisenberg, whereby he has arrived at his famous principle of indeterminacy. According to it, it is never possible for us to determine the simultaneous values of momentum, and positional co-ordinates of any system with an accuracy greater than what is compatible with the inequality $\Delta p \, \Delta q > \frac{h}{4\pi}$.

This natural limitation does not affect the physics of bodies of finite size but makes space-time descriptions of corpuscles and photons impossible. When we proceed to study the behaviour of the elementary particles, our instruments of measurement have an essential influence on the final results. We have also to concede that the contributions of the instrument and the object, are not separately computable from the results as they are interpreted in a classical way with the usual ideas of co-ordinate and momentum accepting thereby a lack of control of all action and reaction of object and instrument due to quantum effects.

It is in this imperative necessity of describing all our knowledge with the usual classical ideas, that Bohr seeks an explanation of the apparently irreconcilable behaviour of corpuscles and radiation in different experiments. For example, if we set our experiments in such a fashion as to determine accurately the space-time co-ordinates, the same arrangement cannot be simultaneously used to calculate the energy momentum relations accurately ; when our arrangements have pushed the accuracy of determining the positional co-ordinates to its utmost limit, the results evidently will be capable only of a corpuscular representation. If, on the other hand, our aim is to determine momentum and energy with the utmost accuracy, the necessary apparatus will not allow us any deter-

mination of positional co-ordinates and the results we obtain can be understood only in terms of the imagery of wave-motion. The apparently contradictory nature of our conclusions is to be explained by the fact, that every measurement has an individual character of its own. The quantum theory does not allow us to separate rigorously the contribution of the object and the instrument and as such the sum total of our knowledge gained in individual cases cannot be synthesised to give a consistent picture of the object of our study which enables us to predict with certainty its behaviour in any particular situation. We are thus doomed to have only statistical laws for these elementary particles and any further development is not likely to affect these general conclusions.

It is clear that a complete acceptance of all the above conclusions would mean a complete break with the ancient accepted principles of scientific explanation. Causality and the universal laws are to be thrown simultaneously overboard. These assertions are so revolutionary that, no wonder, they have forced physicists to opposing camps. There are some who look upon causality as an indispensable postulate for all scientific activities. The inability to apply it consistently because of the limitations of the present state of human knowledge would not justify a total denial of its existence. Granted that physics has outgrown the stage of a mechanistic formulation of the principle, they assert that it is now the task of the scientists to seek for a better formulation. Others of the opposing camp look upon old determinism as an inhuman conception, not only because it sets up an impossible ideal, but also as it forces man to a fatalistic attitude which regards humanity as inanimate automata in the hands of an iron law of causation. For them the new theory has humanised physics. The quantum statistical conception of determinism nestles closer to reality and substitutes a graspable truth for an inaccessible ideal. The theory has brought hope and inspired activity. It constitutes a tremendous step towards the understanding of nature. The features of the present theory may not all be familiar but use will remove the initial prejudice. We are not to impose our reason and philosophy on nature. Our philosophy and our logic evolve and adjust themselves more and more to reality.

In spite of the striking successes of the new theory, its provisional character is often frankly admitted. The field theory is as yet in an unsatisfactory state. In spite of strong optimism, difficulties do not gradually dissolve and disappear. They are relegated to a lumber room, whence the menace of an ultimate divergence of all solutions neutralises much of the convincing force of imposing mathematical symbols. Nor is the problem of matter and radiation solved by the theory of complementary characters. Also we hear already of the limitations of the new theory encountered in its application to nuclear problems.

The quantum theory is frankly utilitarian in its outlook ; but is the ideal of a universal theory completely overthrown by the penetrating criticism of the nature of physical measurements?

Bohr has stressed the unique character of all physical measurements. We try to synthesise their results and we get probabilities to reckon with instead of certainties. But how does the formalism $\frac{h}{2\pi i}\frac{\partial\psi}{\partial t} = H\psi$ emerge as a certain law? The wider the generalisation, the less becomes the content. A universal law would be totally devoid of it. It may nevertheless unfold unsuspected harmonies in the realm of concept. More than ever now, physics does need such a generalisation to bring order in its domain of ideas.

SECTION OF MATHEMATICS AND STATISTICS

President :—B. M. SEN, M.A., F.N.I., I.E.S. (retd.)

THE FUNDAMENTAL EQUATIONS OF QUANTUM MECHANICS.

(Delivered on Jan. 5, 1944)

The object of the following address is to present a connected account of the modern theory of Quantum Mechanics from the stand-point of a mathematician. It is an indisputable fact that experiment has far out-stripped the theory in the particular field and the mathematician has not been able to shed any light on many well-established experimental facts. The progress of theoretical Physics has been due in a large measure to a judicious exercise of physical intuitions and the method of trial and error. But the exposition here given deals mathematically with established results after the preliminary stages have been passed.

The origin of Quantum Mechanics lies in the attempt of Bohr to explain the lines of the Hydrogen spectrum on the basis of Rutherford's atomic model. This is merely a solar system in miniature, the nucleus with a positive charge taking the place of the sun while the planets are represented by electrons with negative charges. But there are grave difficulties in the use of the simple model. It is one of the well-known results of classical Electrodynamics that an accelerated electron radiates energy. And as the electrons in Rutherford's model are always being accelerated, they would radiate energy all the time and must ultimately fall into the nucleus and the atom would ultimately collapse. Bohr made the assumption that there are levels of Energy and that it is absorbed or radiated only when the electron jumps from one level to another. These levels correspond to integral multiple values of a definite quantum of energy h, the Planck's constant. The frequency of radiation or absorption is given by the relation $W_m - W_n = \lambda\nu_{mn}$ where W_m, and W_n are the values of Energy at the two levels. The frequency of radiation, therefore, depends on two numbers m, n leading to the conception of a matrix. With this assumption, Bohr succeeded in explaining the lines of the Hydrogen Spectrum. But it does not seem to be any business of modern theoretical physics to describe or investigate the mechanism of the jump.

At the initial stage, the orbits are supposed to be circular but later, the elliptic nature of orbits is taken into account and the quantum condition is generalised into the form $\int pdq = nh$, where q, p stand respectively for the coordinate and corresponding momentum of the revolving electron. This condition is further generalised into

$$p_r q_s - q_s p_r = \frac{h}{2\pi i}\delta_{rs} \qquad \qquad (1)$$

where $\delta_{rs} = 0$ when $r \neq s$, and $= 1$ when $r = s$.

This introduction of non-commutative Algebra is a turning point in Mathematical Physics. Attempts are then made to find mathematical operations which do not satisfy the law of commutation. The earliest is that of Born, Jordan and Heisenberg, in which dynamical quantities are represented by matrices, which satisfy the non-commutative law.

Though simple problems such as those of the Hydrogen lines are successfully attacked the working is found very difficult in practice. Weyl introduces the group theory, but without much success either.

The most practicable method is that of the Operator Calculus which meets the requirements of equation (1) by regarding the p's as operators with the relation

$$p = \frac{h}{2\pi i}\frac{\partial}{\partial q}.$$

Schrödinger contributes the equation named after him

$$\left\{ H\left(\frac{h}{2\pi i}\frac{\partial}{\partial q}, q\right) - W \right\} \psi = 0 \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

for an electron moving in an electric field, where $H\,(p, q)$ stands for the Hamiltonian Function of classical mechanics and W for the total Energy and derives it by considering the stationary value of the Hamilton-Jacobi expression. No reason is given for the process, but the equation is now to be regarded as the starting point of Modern Atomic Physics and fills the same position as Newton's equations of motion do in classical Mechanics. The characteristic value of W necessary to make ψ an analytic function are the Energy-levels while the characteristic function ψ is later interpreted as the probability function. Thus $\psi^*\psi dv$ represents the probability of the electron being found in the element of volume dv, ψ^* being the conjugate complex of ψ. This replacement of the momentum by a differential operator is a landmark in the progress of atomic physics.

It is then proved that the matrix mechanics of Born and the Wave mechanics of Schrödinger are but two aspects of the same theory. The terms of a matrix representing any dynamical quantity x are given by the equation $x_{mn} = \int \psi^*_m x \psi_n dq$, where dq stands for dq_1, dq_2 . . . dq_s Following the practice of classical mechanics, it is shown that the total energy W and $-t$ can be regarded as a pair of canonical conjugates corresponding to momentum and velocity of an elementary particle. This is in agreement with the Relativity Theory which demands that the space coordinates and the time coordinate multiplied by i should be treated on equal footing.

Dirac then takes over the Poisson Bracket expressions

$$[x\ y] \equiv \sum \left(\frac{\partial x}{\partial q_k}\frac{\partial y}{\partial p_k} - \frac{\partial y}{\partial q_k}\frac{\partial x}{\partial p_k}\right) \text{ as } \frac{ih}{2\pi}[xy] = (xy - yx).$$

The Hamiltonian Equations are then written as

$$pH - Hp = \frac{ih}{2\pi}\dot{p}, \quad qH - Hq = \frac{ih}{2\pi}\dot{q}.$$

The Schrödinger equation for the Hydrogen atom is

$$\nabla^2\psi + \frac{8\pi^2 m}{h^2}\left(W + \frac{e^2}{r}\right)\psi = 0 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

The solution must be analytic at all points. In spherical polar coordinates, if we assume a solution in the form RY, where R is a function or r only, and Y, a function of the angular coordinates, it can be shown that R must be a finite polynomial while Y must be one of the Laplacian Functions $P_l^m(Cos\theta)\,e^{\pm im\phi}$. R is of the form

$$b_1 r^{l+1} + b_2 r^{l+2} + b_3 r^{l+3} \ldots\ldots + b_s r^{l+s}.$$

The three integers $n(=l+s)$, l, m are the so-called quantum numbers and play a fundamental role in the theory of atomic structure. n is the radial quantum number, l, the angular momentum quantum number and m, the axial or magnetic quantum number. There are small discrepancies between theory and experiment, *e.g.*, the square of a quantum number has to be replaced by the product of the number and the next higher integer, n^2 by $n(n+1)$ for example. No explanation has yet been offered, except that the substitution gives better agreement with experimental results.

It follows from the definition itself that $n>l$, $m<l$. Pauli formulates the principle that no two electrons in an atom may have the same quantum numbers and gives an extremely satisfactory explanation of the periodic classification of elements. But no theoretical explanation of the Principle is yet available. There remains however one difficulty that some of the levels show what is called a doubling phenomenon. Dirac guesses that there must be a fourth quantum number and identifies it with the spin of the electron. His deduction of the spin is a work of extreme elegance and ingenuity and is a big step forward in the development of Quantum Mechanics.

The Schrödinger equation for an electron is modified by the application of Einstein's Theory of Relativity according to which the mass of a particle depends on its velocity and is given by $m=m_0\Big/\left(1-\frac{v^2}{c^2}\right)^{\frac{1}{2}}$, m_0 being the rest-mass, v the velocity and c the velocity of light. For an electron moving in the absence of an electro-magnetic field, the classical mechanics provides the wave equation

$$\left\{\frac{W}{c}-(m^2c^2+p_x{}^2+p_y{}^2+p_z{}^2)^{1/2}\right\}\psi=0 \quad . \quad . \quad . \quad . \quad (4)$$

where p_x, p_y, p_z are to be interpreted as operators $\frac{h}{2\pi i}\frac{\partial}{\partial x}$, $\frac{h}{2\pi i}\frac{\partial}{\partial y}$ and $\frac{h}{2\pi i}\frac{\partial}{\partial z}$ and W as $-\frac{h}{2\pi i}\frac{\partial}{\partial t}$.

This is in accordance with the Relativity Theory in which the space coordinates and the time play similar roles. Dirac therefore assumes that this equation should be linear in W, p_x, p_y, p_z and of the form

$$\left[\frac{W}{c}+\alpha_x p_x+\alpha_y p_y+\alpha_z p_z+\alpha_m mc\right]\psi=0 \quad . \quad . \quad . \quad (5)$$

the α's being independent of W and the p's. The α's satisfy relations of the type $\alpha_x{}^2=1$, $\alpha_x\alpha_y+\alpha_y\alpha_x=0$, *i.e.*, they all anticommute with one another and the square of each is unity. Dirac takes the following matrics for the α's which can easily be proved to satisfy the above relations.

He puts $\alpha_x=\rho_1\sigma_x$, $\alpha_y=\rho_1\sigma_y$, $\alpha_z=\rho_1\sigma_z$, $\alpha_m=\rho_3$ where

$$\sigma_x=\begin{bmatrix}0&1&0&0\\1&0&0&0\\0&0&0&1\\0&0&1&0\end{bmatrix}\quad \sigma_y=\begin{bmatrix}0&-i&0&0\\i&0&0&0\\0&0&0&-i\\0&0&i&0\end{bmatrix}\quad \sigma_z=\begin{bmatrix}1&0&0&0\\0&-1&0&0\\0&0&1&0\\0&0&0&-1\end{bmatrix}$$

$$\rho_1=\begin{bmatrix}0&0&1&0\\0&0&0&1\\1&0&0&0\\0&1&0&0\end{bmatrix}\quad \rho_2=\begin{bmatrix}0&0&-i&0\\0&0&0&-i\\i&0&0&0\\0&i&0&0\end{bmatrix}\quad \rho_3=\begin{bmatrix}1&0&0&0\\0&1&0&0\\0&0&-1&0\\0&0&0&-1\end{bmatrix}$$

Dirac then shows that the linear equation is invariant under the Lorentz transformation. Where there is a field given by the scalar potential A_0 and the vector potential A_1, A_2, A_3 the equation is written in the following form, following the classical analogy

$$\left\{\left(\frac{W}{c}+\frac{e}{c}A_0\right)+\rho_1\left(\sigma.p+\frac{e}{c}A\right)+\rho_3 mc\right\}\psi=0.$$

He then shows that in order that this should be capable of being thrown into the form (4) by multiplication with an operator, the electron must be supposed to possess a magnetic moment $-hc/4\pi mc.\ \sigma$ and an electric moment $-i\rho_1 hc/4\pi mc.\sigma$. The electron, therefore, behaves as if it possesses a spin angular momentum $\frac{1}{2}h'\sigma$ where $h'=h/2\pi$.

The analogy of an atom with the solar system is therefore complete. This is a far-reaching discovery leading to the fourth quantum number, the spin, which offers a complete explanation of the doubling phenomenon. But a simple calculation shows that a spin of $\frac{1}{2}h'$, the characteristic values of σ being ± 1, would give a velocity at the periphery far in excess of the velocity of light. This is in clear contradiction of the Theory of Relativity. This anomaly has not yet been cleared and it is usual for more discriminating writers to speak of electrons behaving as if they possessed a spin of $\frac{1}{2}h'$.

Eddington generalised Dirac's matrices into E numbers which satisfy the relations

$$E\mu^2=1,\quad E\mu E\nu+E\nu E\mu=2\delta\mu\nu$$

but they do not seem to lead to any new result or consequence.

The discovery of Neutron adds to the number of the so-called fundamental particles and it is not yet certain whether the proton or the neutron is to be regarded as the elementary particle. Of course, hydrogen is the simplest particle which can be formed by a proton with an electron moving round it, but with a simplifying assumption, I have shown that Dirac's equation leads to a hydrogen-like particle with dimensions of order 10^{-10} cms. which may be identified with the neutron.

The peak of the mathematical theory up to the present has been the formulation of the Lagragian equations to meet the requirements of the Relativity theory as well as the Electro-magnetic theory and their applications to the special problems connected with cosmic rays. Of course, gravitational effects are entirely neglected. It is well-known that in classical mechanics the Maxwellian equations can be derived by Lagrange's method.

The simplest example of a relativistically invariant wave equation is the scalar equation.

$$\Box U - k^2 U = 0$$

where $\Box$ is the operator $\nabla^2 - \partial^2/c^2\partial t^2 = \sum_{i=1}^{4}\partial^2/\partial x_i^2$ and $\kappa = mc/h$.

This can be derived by variation of the function

$$L=\left(\frac{\partial U^*}{\partial xi}\right)\left(\frac{\partial U}{\partial xi}\right)+\kappa^2 U^* U$$

with the principle $\qquad \partial\int L dx_1 dx_2 dx_3 dx_4 = 0$

The usual summation convention is understood.

The current vector is

$$s_k=\varepsilon\left\{\frac{\partial U^*}{\partial x_k}U-\frac{\partial U}{\partial x_k}U^*\right\}$$

in which ε is the charge measured in the natural unit $(hc)^{1/2}$.

The current vector satisfies the equation of continuity

$$\partial s_k/\partial x_k = 0.$$

The Energy-momentum Tensor T_{ik} is defined in this case by

$$T_{ik} = \frac{\partial U^*}{\partial x_i}\frac{\partial U}{\partial x_k} + \frac{\partial U^*}{\partial x_k}\frac{\partial U}{\partial x_i} - L\delta_{ik}.$$

The Energy density

$$W = -T_{44} = -\frac{\partial U^*}{\partial x_4}\frac{\partial U}{\partial x_4} + \text{grad}\, U^* . \text{grad}\, U + k^2 U^* U$$

is always positive, an important consideration.

It has been shown from the property of eigenstates in momentum space that this case leads to only one eigenstate. This particular form of the Lagrangian function must therefore correspond to particles without spin. The quantization has also been successfully carried out.

For particles of spin 1, a skew-symmetric tensor

$$U_{ik} = \frac{\partial U_k}{\partial x_i} - \frac{\partial U_i}{\partial x_k} = -U_{ki}$$

is introduced. It is related to U_k in the same way as the field strengths are relative to the potentials in Electro-dynamics.

We get then $\dfrac{\partial U_{ik}}{\partial x_k} + \kappa^2 U_i = 0$

The corresponding Lagrangian Function

$$L = -\tfrac{1}{2} U_{ik} U^*_{ik} + \tfrac{1}{2} U_{ik}\left(\frac{\partial U_k}{\partial x_i} - \frac{\partial U_i}{\partial x_k}\right) + \tfrac{1}{2}\left(\frac{\partial U_k^*}{\partial x_i} - \frac{\partial U_i^*}{\partial x_k}\right) U_{ik} + \kappa^2 U_i^* U_k$$

gives by the usual variation principle the definition of U_{ik} and the equation satisfied by it above.

The Energy momentum tensor

$$T_{ik} = U_{kr}^* \frac{\partial U_r}{\partial x_i} + \frac{\partial U_r^*}{\partial x_i} U_{kr} - L\delta_{ik}.$$

This was worked out by Proca. Dirac worked out the theory for spin ½. Applications to cosmic showers have been made by Bhabha.

This is where the matter rests at present. But the mathematical treatment is becoming extremely complicated. The development of Theoretical Physics has been of absorbing interest though the mere mathematician is apt to find himself sometimes befogged in the rather uncertain atmosphere of new physical intuitions which frequently lack definiteness, at least at the initial stages.

SECTION OF PHYSICS

President :—D. S. KOTHARI

COLD DENSE-MATTER

(Delivered on Jan. 6, 1944)

From the dawn of Science, natural philosophers have speculated on the atomistic structure of matter, but it was only after the formulation of Newtonian mechanics and developments in analytical dynamics that the atomic concept proved fruitful in interpreting and analysing the physical properties of matter in bulk in terms of the properties of constituent atoms and the laws of interaction between them. It marked a great advance when, on the one hand, Drude, Lorentz and Richardson amongst others recognised explicitly that the general laws of the 'classical kinetic theory of gases' discovered by Maxwell and Boltzmann could be extended to sub-atomic particles *e.g.,* the electrons, and, on the other hand, when Einstein and others applied them to particles of more 'usual' size than gas molecules, *e.g.,* colloid suspensions. However, this extension of classical statistical mechanics to electrons did not meet with any degree of uniform success in all the different problems where it was applied. Thus the theory of metallic conduction, while it gave a fairly satisfactory result for the Weidemann-Franz ratio, was faced with a rather grave difficulty regarding specific heats. Again in astrophysics, the theory of thermal ionization initiated by Saha which has provided the key for the elucidation of stellar spectra is based on the assumption that the behaviour of an electron gas can be described by the classical perfect gas equation. But, as Eddington first pointed out, one met with a difficulty of somewhat peculiar nature concerning the possible ultimate fate of white dwarf stars when one attempted to apply the theory of thermal ionization to the material constituting them. On the whole it appeared that *classical* statistical mechanics applied to electrons led to quite fruitful results, provided the temperature was sufficiently high or the concentration (number of free electrons per unit volume) sufficiently low—conditions which are ideally fulfilled in the case of stellar atmospheres. On the contrary, for comparatively low temperatures or large concentrations one encountered difficulties and contradictions. The situation was changed when in 1926 Fermi, and independently Dirac, found that *classical* statistics was inconsistent with Pauli's exclusion principle, and the electrons obeyed a new statistics which for large temperatures or small concentrations tended to the classical one, but in the case of low temperatures or large concentrations it differed completely or degenerated from the classical form.

The first astrophysical application of Fermi-Dirac statistics was made by Fowler, and this was followed by the work of Frenkel, Majumdar and Stoner amongst others. Milne has incorporated the new statistics in his extensive investigations on stellar structure, and the application of its relativistic modification to equilibrium configurations of white dwarfs has been worked out in complete detail by Chandrasekhar.

I shall deal later at some length with the properties of dense-matter and their astrophysical applications.

It is not the electrons alone which obey Fermi-Dirac statistics, nor does it hold for all kinds of particles. For example, neutrons and protons obey Fermi-Dirac statistics. Photons, alpha-particles, hydrogen-atoms and probably mesons obey what is called Bose-Einstein statistics, after Bose, who first in 1926 formulated it in connection with photons, and Einstein who applied it to material particles. The statistics, Fermi-Dirac or Bose-Einstein, that a particle (or a system) obeys is determined by its spin—both spin and the statistics are non-classical concepts and are essentially non-visualisable in character. *Particles which possess zero or integral units of spin* (the unit being h) *obey Bose-Einstein statistics, whereas particles possessing half-integral units of spin obey Fermi-Dirac statistics.* This connection between spin and statistics, which has been established by the recent work of Pauli and Fierz, provides an illuminating illustration of how the relativity theory discloses connections between concepts which at first sight would appear to be altogether unrelated.

For both Fermi-Dirac and Bose-Einstein Statistics, the number of independent wave functions of the assembly, when its (total) energy lies between assigned limits, is far smaller than what it is for the classical case. This restriction arises because of the permanence of the symmetry characteristics of the wave functions (including spin co-ordinates) describing the stationary states of an assembly of similar systems; the wave function for the assembly is anti-symmetrical in every pair of similar systems for Fermi-Dirac statistics and symmetrical in every pair of similar particles for the Bose-Einstein case. In the new statistics the concept of the similarity or the identity of systems of the same species (*e.g.*, one electron is exactly similar to any other electron) plays a far-reaching role, whereas in classical statistics, it has no special significance. In fact, the concept of similarity is not in (complete) harmony with the classical theory where, unlike quantum mechanics, it is always possible in principle to follow exactly the space-time course of systems and thus even identical systems can always be distinguished from one another —systems which because of their being identical ought to be indistinguishable, are not indistinguishable.

It may be mentioned that for an assembly for which the systems can be assigned permanent or quasi-permanent locations, *e.g.*, the atoms in a crystal lattice, the systems can be regarded as distinguishable, and the number of accessible states for the assembly in such a case becomes identical with the classical result.

The new statistics has proved fruitful in the understanding of atomic problems of the most varied kinds. Thus, it has found application in the theory of magnetism and of metallic conduction, in explaining the intensity variations within rotation bands of symmetric molecules like H_2, in the understanding of ortho- and para- forms of elements, in scattering phenomenon where the incident and the scattering particles are similar, and recently to explain some of the peculiar properties of liquid He II. In the case of a gaseous assembly of similar particles, as already mentioned, for high temperatures or low enough concentrations the new statistics tends to the classical one, whereas, when the temperature is low or the concentration high, there is a wide divergence between them.

These two limiting cases of the new statistics are called ***non-degenerate*** and *degenerate* respectively. In a non-degenerate (*i.e., classical*) gas the pressure depends upon the product of the temperature and the concentration, whereas in degeneracy the pressure is (almost) independent of the temperature for a Fermi-Dirac gas, and independent of the concentration for a Bose-Einstein gas, *i.e.*, one of the variables, temperature or volume is relegated to the background. In the degenerate state the mean de Broglie wave length of the particles is large compared to the average distance of separation between them, whereas for non-degeneracy, the reverse is the case.

In discussing the properties of a gas, whether in the state of degeneracy or non-degeneracy, it is convenient to consider two limiting cases, which are usually called the *non-relativistic* and the *relativistic* cases. In the non-relativistic case the average kinetic energy per particle is negligible compared to its rest-mass energy, and it is vice versa in the relativistic case.

The various cases of degeneracy and non-degeneracy and the relevant discriminants are enumerated below :—

Fermi-Dirac Statistics	
non-relativistic non-degenerate $\frac{nh^3}{g(2\pi mkT)^{3/2}} << 1 \; ; \; \frac{mc^2}{kT} >> 1$	relativistic non-degenerate $\frac{n}{8\pi g}\left(\frac{ch}{kT}\right)^3 << 1 \; ; \; \frac{mc^2}{kT} << 1$
non-relativistic degenerate $\frac{nh^3}{g(2\pi mkT)^{3/2}} >> 1 \; ; \; \frac{h}{mc}\left(\frac{3n}{4\pi g}\right)^{1/3} << 1$	relativistic degenerate $\frac{n}{8\pi g}\left(\frac{ch}{kT}\right)^3 >> 1 \; ; \; \frac{h}{mc}\left(\frac{3n}{4\pi g}\right)^{1/3} >> 1$
Bose-Einstein Statistics	
non-relativistic non-degenerate $\frac{nh^3}{g(2\pi mkT)^{3/2}} << \zeta(3/2) \; ; \; \frac{mc^2}{kT} >> 1$	relativistic non-degenerate $\frac{n}{8\pi g}\left(\frac{ch}{kT}\right)^3 << \zeta(3) \; ; \; \frac{mc^2}{kT} << 1$
non-relativistic degenerate $\frac{nh^3}{g(2\pi mkT)^{3/2}} >> \zeta(3/2) \; ; \; \frac{mc^2}{kT} >> 1$	relativistic degenerate $\frac{n}{8\pi g}\left(\frac{ch}{kT}\right)^3 >> \zeta(3) ; \; \frac{mc^2}{kT} << 1$

T—Temperature of the gas.
m—Mass of the particle.
n—Number of particles per unit volume.
g—Weight factor of the particle by virtue of its internal structure (For electrons $g=2$).
c—Velocity of light.
k—Boltzmann constant.
h—Planck constant.
$\zeta(s)$ Riemann-Zeta function. $\zeta(3/2)=2{\cdot}612$; $\zeta(3)=1{\cdot}202$.

In the non-degenerate case, the Gibbs free energy per particle is negative and large compared to kT. For degeneracy in the Fermi-Dirac case it is positive and large compared to kT, whereas for Bose-Einstein degeneracy it is zero.

In Bose-Einstein degeneracy the particles in the assembly are distributed between two phases, the so-called *condensed* phase and the *energetic* phase—these two phases are co-extensive in (ordinary) space but separated in momentum space. The condensed phase is constituted of particles that are in the state of the lowest kinetic energy possible for a particle in the assembly, and in the non-relativistic approximation the number per unit volume in this phase is given by

$$n-n^* \; ; \; n^*=\zeta(3/2)\frac{g(2\pi mkT)^{3/2}}{h^3}.$$

The energetic phase contains n^* particles per unit volume. London and Tisza have recently made use of the properties of the condensed phase to explain in a rather qualitative way some of the peculiar feature of the behaviour of liquid He II.

During recent years the theoretical study of liquid structure has attracted considerable attention and several models for the liquid state have been proposed. The model that interests us here is that of Fürth where a liquid is assumed to be a continous medium permeated with 'holes'. The holes are continually varying in size which is subject to a distribution law easily derived by the usual methods of statistical mechanics. The average radius of a hole is controlled by the temperature and the surface tension of the liquid. It is not necessary to go into the details of the model, but only refer to the possibility of the existence of a *condensed phase* for holes which presumably obey Bose-Einstein statistics. As the number of holes cannot exceed the number of molecules present in the liquid, the condensed phase will appear when the temperature is lower than

$$T^*=\frac{1\cdot 7}{k}\left(\frac{h^8\sigma^7}{m^2\rho^2}\right)^{1/11},$$

where σ is the surface tension, ρ the density of the liquid and m the mass of the molecule. We shall not pause here to consider the application of the hole theory to liquid He II, but pass on to describe results which appear to be of wider interest. For the hole-model of a liquid, it is obviously important to construct formally the Schrödinger equation for a hole and determine the eigen-values for its energy. The energy of the ground state is found to be

$$E_0=3\cdot 1\left(\frac{h^4\sigma^5}{\rho^2}\right)^{1/7},$$

and for the higher states the approximate expression is

$$E_n=3\cdot 6\left(n+\frac{7}{10}\right)^{4/7}\left(\frac{h^4\sigma^5}{\rho^2}\right)^{1/7}, \quad (n=1,\ 2,\ 3,\ \ldots\ .).$$

The 'classical' radius r of a hole in the ground state is given by

$$E_0=4\pi\sigma r^2.$$

The above theory immediately gives expressions for the melting point T_m and the latent heat of fusion Q_m in terms of surface tension and density of the liquid. We obtain

$$T_m = \frac{3\cdot 1}{k}\left(\frac{h^4\sigma^5}{\rho^2}\right)^{1/7},$$

and further the theory requires that the value of (where ΔV_m is the increase in molar volume on melting)

$$\frac{Q_m/RT_m}{N_m/N}\,; \quad N_m = \frac{\Delta V_m}{\frac{4}{3}\pi r^3}$$

should be unity. It is found that the agreement between theory and observation is not unsatisfactory. One is tempted to observe that the energy levels of a hole may reveal their presence in scattering and ultrasonic phenomena, but in the present state of the theory it is scarcely worthwhile to pursue this topic further here.

It is well known that equilibrium (blackbody) radiation represents the completely relativistic case (zero rest-mass) of Bose-Einstein degeneracy. The realization of non-degenerate radiation is dependent upon the possibility of direct interaction between photons, and is thus connected with the non-linear developments in the electro-magnetic field theory as in the investigations of Born, and Euler and Heisenberg. Non-degenerate radiation is not to be confused with *dilute* radiation. (Dilute radiation is not an equilibrium radiation in the thermodynamic sense. When equilibrium radiation becomes dilute, there takes place no redistribution of energy in the different frequencies, but the energy in the different frequencies is merely lowered by a constant factor.) It is possible that the existence of non-degenerate radiation will be found to be partly responsible for departure from blackbody radiation met with in astrophysical studies, but at the present stage it is an open question.

The transformation of radiation into electron-positron pairs is a fact of observation, and further as mesons on decay transform into electrons, it follows that equilibrium radiation will contain electron and meson pairs (and neutrinos and antineutrinos), their number depending on the temperature. If ξ_+ and ξ_- denote the Gibbs free energy per particle for positive and negative electrons respectively, then, assuming the total charge of the electrons to be zero, we have

$$\xi_+ + \xi_- = -2mc^2,$$

and as $$\xi_+ = \xi_-\,, \quad \xi_- = -mc^2,$$

where m is the rest mass of the electron. As the free energy is equal to $-mc^2$, it follows that the electrons in equilibrium with radiation will never constitute a degenerate gas. However, for particles obeying Bose-Einstein statistics the gas will be non-degenerate in the non-relativistic approximation but degenerate in the *completely* relativistic case. The electron concentration in equilibrium with radiation is given by

$$n = \frac{2(2\pi mkT)^{3/2}}{h^3}\exp(-mc^2/kT) \qquad \text{(non-relativistic case)}\ mc^2/kT \to \infty,$$

$$n = 12\pi\zeta(3)\left(\frac{kT}{ch}\right)^3 \qquad \text{(relativistic case)}\ mc^2/kT \to 0.$$

For mesons (mass $\bar{m}$) we have similarly

$$n = g\,\frac{(2\pi\bar{m}kT)^{3/2}}{h^3}\exp\left(-\bar{m}c^2/kT\right), \qquad \begin{array}{c}\text{(non-relativistic case)}\\ \bar{m}c^2/kT \to \infty,\end{array}$$

$$n = 8\pi g\zeta(3)\left(\frac{kT}{ch}\right)^3, \qquad \begin{array}{c}\text{(relativistic case)}\\ \bar{m}c^2/kT \to 0.\end{array}$$

The last equation is identical with that for photons if we put $g=2$. It is interesting to observe that if the rest-mass m of the electron (or $\bar{m}$ for the meson) were to vary continuously over any range, then, the total concentration of electrons (or mesons) in equilibrium with radiation would tend to infinity. Particles which completely transform into radiation must, therefore, possess discrete rest-masses.

When the assembly is subject to a gravitational field, the discussion of the equilibrium between electrons, mesons, and radiation becomes somewhat complicated—the Gibbs free energy for radiation no longer vanishes at all points of the assembly, *i.e.*, the radiation becomes non-degenerate, the degree of non-degeneracy depending on the strength of the field.

After this somewhat desultory digression, we return to our main object which is to describe the essential properties and astrophysical applications of 'degenerate matter'. Degenerate matter is a material which is composed of ionized atoms and free electrons, the free electrons constituting a degenerate gas in the sense of Fermi-Dirac statistics. It may be stated at once that the temperatures with which we shall be concerned, and in fact those that occur in almost all astrophysical discussions, are too low for equilibrium radiation to influence in any way the number of electrons present in the assembly, the number being completely determined by its chemical composition.

We now ask the question how or under what conditions atoms become ionized and generate a gas of free electrons. What conditions force the electrons to leave their atomic dwellings and wander in the no atom's land between the atoms? There are two ways in which atoms become ionized: (1) Temperature ionization and (2) Pressure ionization.

The theory of temperature or thermal ionization was given by Saha about twenty years ago, and, if the value of a discovery is to be judged by the fruitfulness of its consequences, the discovery of Saha should be considered one of the most important in modern physics. The theory was later extensively developed by Fowler and Milne. Saha's theory is based on the assumption that the free electrons constitute a *classical* perfect gas and will, therefore, be valid only so long as the electron concentration is low and the temperature high enough such that

$$A_0 = \frac{nh^3}{2(2\pi mkT)^{3/2}} << 1\,.$$

Taking as an illustration the simple atomic reaction

$$X \rightleftharpoons X^+ + e;$$

where X symbolizes a neutral atom, X^+ the singly ionized atom and e

the electron, the Saha-formula (neglecting the effect of excited states) gives

$$n_+ = \frac{g_+}{g_a}\,\frac{e^{-U/kT}}{A_o},$$

in which n_+ represents the concentration of the ionized atoms, n_a that of the neutral atoms and U the energy required to ionize an atom (ionization potential). It shows that ionization will be practically complete when $kT>>U$, and ionization will be negligible when $kT<<U$, unless A_o becomes extremely small. In thermal ionization, therefore, temperature plays a dominating role and pressure or density only a secondary part, and hence it is aptly called thermal or temperature ionization.

In degenerate matter the behaviour of free electrons departs widely from that of a *classical* gas and in consequence the Saha-formula loses its validity and the degree of ionization must be investigated on other lines. The investigation of the degree of ionization in *cold* matter is of importance in astrophysics, particularly in researches dealing with the internal constitution of white dwarf stars and also, as has been recently shown, in predicting a maximum radius for a *cold* stellar body. (The words *hot* and *cold* are used here in a technical sense. Matter will be called *hot* when any *free* electrons present constitute a non-degenerate gas, and it will be referred to as *cold* when any *free* electrons present constitute a degenerate gas.)

In *cold* matter the electrons will fill the lowest available levels, and hence free electrons will exist only when no bound-levels are available for the electrons to fall into. When initially unionized *cold* matter is compressed (*i.e.*, its density increased) to such an extent that the orbits of the outermost electrons of neighbouring atoms begin to overlap, then, these outermost—or as they are called 'valence' or 'optical' electrons—cannot be regarded as belonging to individual atoms. They are no longer bound to their own atoms (but wander, as it were, in a no atom's land) and constitute a free electron gas. The average velocity of the free electron will be nearly equal to the orbital velocity of the outermost (*i.e.*, most loosely bound) electron in the ion. The situation therefore is parallel to that met with in the theory of the ionization of heavy ions produced in uranium fission where the velocity of the ion is nearly equal to the orbital velocity of the most loosely bound electron attached to the ion.

If we continue to compress the material still further the orbits of the outermost electrons of the already ionized atoms would, in their turn, on account of the closeness of packing be obliterated, or as we say in the electron theory of metals, the levels of different atoms get fused into continuous bands. The ionization would thus continue to increase with the compression of the material, till it is reduced to free electrons and bare nuclei. The degree of ionization in degenerate matter is thus determined essentially by its density on pressure (for in degenerate matter, the pressure depends mainly on the density and very little on the temperature), and for this reason it is spoken of as pressure ionization, a term originally due to Bridgman. The above description of pressure ionization is admittedly very crude, but it serves to indicate the essential distinction between thermal and pressure ionizations:

(i) Thermal ionization occurs in *hot* or non-degenerate matter; pressure ionization in *cold* or degenerate matter:

(ii) If, keeping temperature constant, the density be reduced, then, the degree of ionization is increased for thermal and decreased for

pressure ionization. The effect of change of density is much greater for pressure than for thermal ionization:

(iii) If, keeping density constant, the temperature be increased, then the degree of ionization is increased in thermal but remains practically unaffected in the case of pressure ionization (unless the increase in temperature be so large that the degeneracy of the electron gas is removed and pressure ionization passes into thermal ionization).

Let us consider *cold* matter compressed to such an extent that some at least of the outer atomic orbits overlap, and, therefore, the electrons which occupied these levels are rendered (or squeezed) free—in other words, we contemplate conditions such that pressure ionization occurs. The relation between the degree of ionization and pressure can be derived in two alternative ways, the results obtained being in substantial accord with each other. In the first method use is made of the values of successive ionization potentials which have been calculated by Hartree in some cases. In the other method we suppose the material divided into similar spherical cells—each cell containing a nucleus and Z electrons. In general some of these electrons will be bound and some will be free. The radius a of the cell will be connected with the density by the relation (ignoring a factor of the order unity which depends upon several factors, particularly the lattice arrangement of the atoms).

$$a^3 \frac{\rho}{AH} = 1.$$

An easy application of the *virial theorem* with certain simplifying assumptions gives a quantitative relation between the degree of ionization and the density or pressure of the material.

It is usual to express the degree of ionization in terms of what is called the *mean molecular weight per free electron* (μ). If we suppose the mass of the material to be equally shared amongst all the free electrons present, then, each electron will receive a mass μ, the unit of mass being the H-atom. The number of free electrons per unit volume will be given by

$$n = \frac{\rho}{\mu H},$$

where ρ is the density of the material. It may be noted that the usual definition of μ is the average weight *per particle*, but as in a degenerate gas the 'heavy particle' is to be consistently ignored, we define μ as the molecular weight *per free electron*. We shall speak of it as the electron molecular weight to distinguish it from the usual definition. For ionized hydrogen μ is 0.5 per particle and unity per free electron.

Let us consider the material to be composed of atoms of one kind only of atomic weight A and atomic number Z, then if the atoms in it are on an average r-times ionized,

$$\mu = A/r.$$

For singly ionized material $\mu = A$, and for complete ionization $\mu = \mu_0$, where $\mu_0 = A/Z$. It is important to observe that though for incomplete ionization the value of μ depends on the chemical constitution of the material, *in the case of complete ionization it is practically equal to 2 for all elements except (i) hydrogen for which it is unity and (ii) the helium isotope He*^{3} *for which it is 1.5.*

The theory of pressure ionization gives

$$\mu = \mu_0 \Big/ \left[1 - \left(\frac{\Delta ZA}{\rho}\right)^{1/3}\right]^{3/5},$$

where

$$\Delta = (24\pi^2)\left[\frac{me^2H^{1/3}}{h^2}\right]^3,$$

e being the electron charge. If ρ^* denotes the density of the material when it is singly ionized ($\mu = A$), then, we have

$$\rho^* = \Delta ZA\left(1 - \frac{1}{Z^{5/3}}\right)^{-3}$$

and

$$\mu = \mu_0 \Big/ \left[1 - \left(\frac{\rho^*}{\rho}\right)^{1/3}\left(1 - \frac{1}{Z^{5/3}}\right)\right]^{3/5}.$$

The several simplifying assumptions which are introduced in the theory render it particularly inaccurate in the region of low ionization. In the case, therefore, where ρ^* can be estimated from other considerations (for example in the case of alkali metals we might take it to be the density of the normal metal), it is sometimes advantageous to use this rather than the theoretical value in the expression for μ.

The ionization increases, at first rapidly then slowly, with increasing density or pressure. The following table for the case of helium provides an illustration.

Helium ($A=4$, $Z=2$).

Percentage Ionization	μ	Density gm./cm.^{3}	Pressure dyne/cm.^{2}
0	∞	0·35	0
20	10	0·43	$5{\cdot}22 \times 10^{10}$
40	5	0·72	$3{\cdot}96 \times 10^{11}$
60	3·33	1·84	$3{\cdot}69 \times 10^{12}$
80	2·50	11·6	$1{\cdot}28 \times 10^{14}$
100	2·00	∞	∞

In connection with pressure ionization it is interesting to note that, following the lines of the theory of metals given by Wigner and Seitz, Wigner and Huntington have shown the possibility of the existence of metallic hydrogen under a pressure of the order of 10^6 atmospheres. (According to the above equation, hydrogen under a pressure of 10^5 atmospheres will be about 60% ionized). Recently the properties of dense hydrogen have been discussed in detail by Critchfield.

As is well known, a white dwarf star possesses a much smaller luminosity than other stars of the same mass and spectral type. About a dozen such stars are known, the best example being the companion of Sirius which has nearly the same mass as the Sun, but has less than 1/300th of its luminosity. Its radius as estimated both from its effective

temperature and the relativity shift of its spectral lines is somewhat more than the diameter of the Earth. The mean density is therefore very large ; it is about 10^5 gm./cm.^{3}. A low luminosity, a high effective temperature and a very large mean density are the general features of white dwarfs. It is believed that a white dwarf is a fairly common object in the sky, but because of its low luminosity it escapes observation. The following table (after Kuiper) gives particulars of white dwarfs about which fairly reliable data are available :—

Name	Effective Temperature $T_e \times 10^{-3}$ degrees	Luminosity $L/L_\odot$	Mass $M/\odot$	Radius $R \times 10^{-9}$ cm.	Mean Density $\rho_m \times 10^{-6}$ gm./cm.^{3}
Sirius B.	9·5	0·0030	0·95	1·4	0·17
40 Eridani B. ..	13·5	0·0080	0·46	1·1	0·16
Van Maanen 2 ..	8·2	0·00016	2·0	0·43	12

$L_\odot$ = Luminosity of the sun ($3·8 \times 10^{33}$ erg/sec.).
$\odot$ = Mass of the sun ($2·0 \times 10^{33}$ gm.).

The existence of the high density in white dwarfs presents by itself no special difficulty, for, in the case of ionized material any density (perhaps) short of the density of nuclear matter (log $\rho \sim 15$) is permissible. However, if for a moment we forget about pressure ionization and the inapplicability of Saha's formula to degenerate matter, the white dwarf star will provide us with a curious paradox which is worth describing.

When the white dwarf ultimately cools down to a sufficiently low temperature, it must, as the theory of thermal ionization requires, consist of unionized atoms. But unionized material, even if its constituent atoms were almost in contact, could not have a density much greater than unity. Thus, as the star cools down, it must expand about a hundred times in size, but this is asking the star to do an impossible thing ; it will not have sufficient energy to do the enormous work against gravity which the expansion would entail. The star must cool, but it needs energy to cool and of this it does not possess enough, therefore, it cannot cool, but cool it must and so on ; and we have entangled ourselves into a morass of 'stellar stupidity'. This is the Eddington-paradox referred to earlier and in his own words : *"The star will need energy in order to cool. . . .* It would seem that the star will be in an awkward predicament when its supply of sub-atomic energy ultimately fails. Imagine a body continuously losing heat but with insufficient energy to grow cold."

A possible way out of this impasse is to refuse to recognize that the star will ever start cooling—it will continue to shine and due to the gravitational energy released continue to get hotter and hotter, till, perhaps, it ends at last as a gigantic mass of density comparable to that of nuclear matter. But such a hypothesis would land us in fresh difficulties regarding its luminosity—it will be escaping Scylla to fall into Charybdis. However, it is now time to remind ourselves that we have forced this 'stellar buffoonery' on the white dwarf by wilfully forgetting that in cold matter ionization is due to pressure and not temperature. If we assume that in a white dwarf the matter is in the state of dege-

neracy, then, the star can cool without affecting the degree of ionization and *hence cooling no longer necessitates swelling.* But is our solicitude for the ultimate fate of the white dwarf the only reason for assuming it to be composed of degenerate matter? We shall not stop at this stage to answer this question, but proceed to investigate the properties of a spherical mass of ionized matter in the state of complete degeneracy.

To keep to the essentials of the argument we shall at first assume the material to be composed of only one kind of atoms (atomic weight A, atomic number Z), and ignore the density-variation inside the model. As Rosseland showed long ago, an electrical field is set up in a star which prevents any appreciab'e separation between the free electrons and the ions, and for a model of uniform density we must have

$$AHu + e\frac{A}{\mu}v = o,$$

where u is the gravitational potential and v the electostatic potential, both measured from the centre: $u = v = o$ at $r = o$. If ξ denotes the Gibbs free energy pei electron, then, we have

$$\begin{aligned} \xi_0 - \xi_1 &= mu_1 - ev_1 \\ &= H\mu u_1, \end{aligned}$$

where the suffixes $_0$ and $_1$ represent the values at the centre ($r=o$) and the surface ($r=R$) respectively. ($mu_1 - ev_1$) is the work done in carrying one electron from the centre to the boundary. Taking account of the effect of relativistic mechanics, the expression for ξ_0 is

$$\xi_0 = mc^2 \left\{ (1 + x^2)^{1/2} - 1 \right\},$$

where $$x = \frac{h}{mc}\left(\frac{3n}{8\pi}\right)^{1/3} = \frac{h}{mc}\left(\frac{9M}{32\pi^2\mu H}\right)^{1/3}\frac{1}{R},$$

and substituting $\xi_1 = o$, and $u_1 = \frac{GM}{2R}$, we obtain

$$R = \frac{\alpha l_0}{\mu^{5/3}}\left(\frac{\odot}{M}\right)^{1/3}\left\{1 - \left(\frac{M}{M_1}\right)^{4/3}\right\},$$

in which $$\alpha = \left(\frac{9\pi}{4}\right)^{2/3} \sim 3\cdot 68,$$

$$l_0 = \frac{\hbar^2}{mH^{5/3}G\odot^{1/3}} \sim 6\cdot 18 \times 10^8 \text{ cm.},$$

and $$M_1 = (18\pi)^{1/2}\frac{H\gamma_2^{3/2}}{\mu^2} \sim \frac{13\cdot 9\odot}{\mu^2}.$$

γ_2 represents the large dimensionless number, that can be constructed from the atomic constants and the constant of gravitation,

$$\gamma_2 = \frac{\hbar c}{GH^2} \sim 1\cdot 69 \times 10^{38}.$$

l_0 is a length characteristic of the white dwarf theory and M_1 is the Chandrasekhar-Stoner limiting mass.

The radius of the configuration decreases with increasing mass and vanishes when M approaches the critical value M_1. In predicting a vanishing radius for the critical mass and a negative radius for a larger mass, the equation has obviously gone astray. Indeed as M increases and approaches the value M_1, the equation transgresses the bounds of its validity. The energy lost by a mass M when it has contracted to a radius R, is of the order of GM^2/R, and, as this can never exceed the total initial energy Mc^2, the radius R must be greater than R_0 (which is called the gravitational radius),

$$R_0 \sim \frac{GM}{c^2} \sim 1 \cdot 5 \frac{M}{\odot} \text{ km.} ;$$

a stellar counterpart of the relation ($a \sim e^2/mc^2$) for an electron.

It is easy to modify the mass-radius relation to take account of this, and the result is that as the mass increases, the radius of the configuration at first decreases, then attains a minimum value and finally increases with increasing mass. The density of stellar matter for a mass in the neighbourhood of, or exceeding M_1, is of the order of $H\left(\frac{cH}{\hbar}\right)^3$, the nuclear density.

However, there is another reason why the above mass-radius relation becomes invalid in the neighbourhood of the critical mass, and this reason persists even when the equation is modified to take account of the loss of mass accompanying the loss of energy due to contraction. When the concentration of the free electrons exceeds $1 \cdot 1 \times 10^{31}$ per cm.^{3}, the maximum energy of the Fermi-Dirac distribution for a degenerate gas is greater than the mass-difference between a neutron and a proton, and the free electrons, therefore, will combine with protons and transform them into neutrons, that is, protons cannot exist when the electron concentration is larger than $1 \cdot 1 \times 10^{31}$ per cm.^{3}. And, further, if the concentration exceeds about $3 \cdot 6 \times 10^{33}$ per cm.^{3}, the electrons will begin to disappear by combining with other nuclei. From this it follows that a white dwarf possessing a mass greater than the sun (more precisely $\frac{4\odot}{\mu_0^2}$) cannot contain hydrogen in its interior. White dwarfs of smaller mass may contain hydrogen, though for reason which are discussed later, this is extremely improbable. As the mass M approaches the critical value M_1, a detailed discussion of the physical situation becomes extremely complicated. In the sequel we shall only consider masses small compared to M_1 for which the mass-radius relation reduces to

$$R = \frac{\alpha l_0}{\mu^{5/3}}\left(\frac{\odot}{M}\right)^{1/3},$$

a result that could have been obtained directly by taking the non-relativistic expression for ξ.

It is worth noting that if the effect of the electrostatic field were ignored and the gravitational potential alone considered the value of l_0 (and hence R) would be increased by a factor H/m and the critical mass by a factor $(H/m)^{3/2}$.

In the above derivation of the mass-radius relation, in order to emphasise the essentials of the argument, we ignored the variation of density (and μ) inside the configuration. But before we ask the question

as to what value is to be assigned to μ in this relation it is worthwhile to free ourselves from the limitation of a uniform density model. If ξ and ξ_+ denote the Gibbs free energy for the electron and the ion respectively, we have (taking the material of atomic weight A and atomic number Z)

$$\frac{d\xi}{dr} = -m\frac{du}{dr} + e\frac{dv}{dr},$$

$$\frac{d\xi_+}{dr} = -AH\frac{du}{dr} - \frac{Ae}{\mu}\frac{dv}{dr},$$

$$\nabla^2 u = 4\pi\rho G\ ;\ \nabla^2 v = -4\pi s\ ;\ s = \frac{A}{\mu}n_+ - n\ ;\ \rho = AHn_+ + mn,$$

where ρ is the mass density and s the charge density, n_+ the concentration of the ions and n of the free electrons. It is necessary to assume some relation between ξ_+ and ξ in order to reduce the above system of equations to a single differential equation, and we shall take

$$\xi_+ / \xi = \lambda \text{ (a constant)},$$

which will conform to the physical situation we are contemplating. The constancy of ξ_+ / ξ requires that Zn_+/n is constant throughout the configuration. After a little calculation we find

$$\frac{1}{r^2}\frac{d}{dr}\left(r^2\frac{d\xi}{dr}\right) = -\frac{4\pi G\mu^2H^2}{1+\lambda\mu/A}n.$$

It is easy to see that for complete degeneracy $\lambda \sim m/H$ and hence we have

$$\frac{1}{r^2}\frac{d}{dr}\left(r^2\frac{d\xi}{dr}\right) = -4\pi G\mu^2H^2 n.$$

This equation may be compared with the Thomas-Fermi equation for an atom,

$$\frac{1}{r^2}\frac{d}{dr}\left(r^2\frac{d\xi}{dr}\right) = 4\pi e^2 n.$$

On substituting the expression for ξ we obtain Chandrasekhar's equation investigated by him in complete detail. Restricting ourselves to the non-relativistic case we have Emden's equation of index $3/2$. Its solution which possesses no singularity at the centre ($r=0$) gives

$$R = \frac{\alpha_0 l_0}{\mu^{5/3}}\left(\frac{\odot}{M}\right)^{1/3}.$$

where
$$\alpha_0 = \left(\frac{9\pi^2\omega^0_{3/2}}{128}\right)^{1/3} \sim 4\cdot51\ ;$$

$\omega^0_{3/2}$ is a constant (132·4) characteristic of Emden-solution of Emden's equation of index $3/2$.

We shall now revert to the theory of pressure ionization and incorporate it in the mass-radius relation given above. We shall disregard the variation of μ inside the configuration—detailed calculations by Auluck taking account of this variation have shown that its effect is almost

For information of the Members of the General Committee.

INDIAN SCIENCE CONGRESS ASSOCIATION

Extracts from the Minutes of the Meeting of the Finance Committee

held on Thursday, November 25, 1943.

2. The revised estimates, the budget estimates for 1943-44 and the statement of the Treasurer on the financial position of the Association were discussed.

It was noted that out of the sum of Rs. 19,000 in the current year's budget provided for outstanding bills on account of the Proceedings of the Sessions 1941 and 1942 and for printing expenses for the Calcutta Session (1943), a sum of Rs. 11,541-13-6 has been disbursed up to 20-11-43 and Rs. 2,938-2-6 will be spent during the financial year for bills received, thus making full payment of the outstanding bills and all bills for the Proceedings of the Calcutta Session. This satisfactory position has been rendered possible by the fact that the Proceedings of the last Calcutta Session had a smaller volume than those of the previous years.

Last year Securities held in the Reserve Fund of the Association of face value of Rs. 5,000 were sold to meet liabilities. This year a sum of Rs. 5,250 has been received in response to appeals and has been utilised to meet printing expenses.

At the end of the financial year the position with regard to printing expenses will be as follows:

The bills for the parts of the Proceedings for the 31st Session (Delhi, 1944) which are already in Press, are expected to amount to Rs. 3,000. For the remaining parts which will be printed during the coming year, the expenditure is expected to be Rs. 3,000. Job printing works will cost Rs. 800. The total expenses for the Session are thus expected to amount to Rs. 7,000. The subscriptions received for the Delhi Session have been practically wholly spent during the current year (1942-43). The above expected bills will have to be met from the receipts on account of subscriptions for the 32nd Session (financial year 1943-44). It will thus be seen that although we have managed to meet the long outstanding debts we are still in arrears to the extent of about Rs. 7,000. In the budget estimates a provision has been made for Rs. 10,000 for printing which includes Rs. 3,000 to be spent for the Proceedings of the 32nd Session.

The closing balance of the General Fund Account of the Association on 20-11-43 was Rs. 4,751-6-9. After the payment of Rs. 2,938-2-6 explained above and other bills, the closing balance at the end of the year (on November 30, 1943) is expected to be Rs. 1,300. It is not possible to manage with this opening balance till June 1944 when the major portion of membership subscriptions is received and it will be necessary to draw upon the current account of the Reserve Fund which shows a balance of Rs. 3,127-3-6. This balance includes Rs. 2,195-7-6 received from the Reception Committee (Calcutta Session), Rs. 600 on account of life membership fees received during the year 1942-43 and Rs. 331-12-0 on account of interest on Investments and refund of income tax.

The following factors have contributed to ease the seriousness of the financial position of past years:

(*a*) Increase of Ordinary and Full Session Membership subscriptions from Rs. 10 to Rs. 12, sanctioned by the General Committee.

(*b*) Donation of Rs. 5,250, of which Messrs. Tata Iron and Steel Co., Ltd., Jamshedpur have contributed Rs. 5,000.

(*c*) Contribution of Rs. 2,195-7-6 by the Reception Committee of the Calcutta Session (1943).

(*d*) Enforcement of Rules for inclusion of materials in the Proceedings and the suspension of certain circulars and lists.

The following budget estimates for the year 1943-44 were approved:

Budget Estimates for the year, 1st December, 1943 to 30th November, 1944.

RECEIPTS	Rs.	PAYMENTS	Rs.	Rs.
		Establishment:		
Members' Subscriptions ...	11,500	Salary	2,610	
		Dearness Allowance ...	576	
Sale of Publications ...	500	Allowance to Clerk of the Second General Secretary	100	
				3,286
		Audit Fee	...	50
		Travelling Expenses ...	...	400
Miscellaneous (per contra)	300	Postage	...	1,500
		Printing	...	10,000
		Contingency and Stationery	...	450
		Furniture and Fittings ...	...	100
		Bank Charges ...	...	50
	Rs. 12,300			Rs. 15,836

Note.—The estimated deficit of Rs. 3,536 is to be partly met from the opening balance and partly from the balance in the current account of the Reserve Fund of the Association.

Receipts and Payments Account for the year ending 30th November, 1943

RECEIPTS

Receipts	Rs. A. P.	Rs. A. P.
To Balance as on 1st Dec., 1942 :—		
Reserve Fund Investments—		
4% Loan 1960-70 Face Value of Rs. 5,000/- at cost ...	5,918 9 4	
3% G. P. Notes Face Value of Rs. 1,000/- at cost ...	945 3 0	
With Imperial Bank of India in Current A/c.	2,045 1 6	
Imprest Cash (as certified) ...	115 0 0	
		9,023 13 10
,, Subscriptions—		
Ordinary & Session Members	11,646 2 6	
In Advance	24 0 0	
Life Members	750 0 0	
		12,420 2 6
,, Interest on Investments ...	...	337 12 0
,, Sale of Publications ...	...	885 11 6
,, Contributions	...	7,445 7 6
,, Miscellaneous Receipts—		
Bank Charges	16 8 6	
Printing	598 14 6	
Postage	76 9 0	
		692 0 0
Total ...		Rs. 30,804 15 4

PAYMENTS

Payments	Rs. A. P.	Rs. A. P.
By Printing	...	14,510 4 3
,, Postage and Telegrams ...	...	1,160 15 6
,, Salaries and Allowances ...	...	2,986 0 0
,, Audit Fees	...	50 0 0
,, Grant to Sub-Committee on 'Science and its Social Relations'	...	50 0 0
,, Bank Charges	...	52 5 6
,, Contingency :		
Stationery	218 13 9	
Local Conveyance ...	46 12 9	
Badges	100 0 0	
Miscellaneous	29 12 6	
		395 7 0
,, Balance –		
Reserve Fund Investments :—		
4% Loan 1960-70 Face Value of Rs. 5,000/- at cost ...	5,918 9 4	
3% G. P. Notes Face Value of Rs. 1,000/- at cost ...	945 3 0	
With Imperial Bank of India ...	3,276 6 6	
With Imperial Bank of India in Current A/c.	1,344 12 3	
Imprest Cash (as certified) ...	115 0 0	
		11,599 15 1
Total ...		Rs. 30,804 15 4

Examined with the books and vouchers and found in accordance therewith.

6, Church Lane,
Calcutta, December 23, 1943.

RAY & RAY,
Chartered Accountants
Registered Accountants } *Auditors.*

J. N. MUKHERJEE,
Treasurer.

negligible—and replacing the density in the expression for μ by the mean density of the configuration, we have

$$\mu = \mu_0 \Big/ \left[1 - \left(\frac{\Delta ZA}{3M/4\pi R^3}\right)^{1/3}\right]^{3/5},$$

and finally we obtain

$$R\left[\left(\frac{M_0}{M}\right)^{1/3} + \left(\frac{M}{M_0}\right)^{1/3}\right] = 2R_0$$

where $$R_0 = 2\cdot 11 \left(\frac{\hbar}{mc}\right)\left(\frac{\hbar c}{HeG^{1/2}}\right)\frac{Z^{2/3}}{A} = 12\cdot 5 \times 10^9 \frac{Z^{2/3}}{A} \text{ cm.}$$

$$M_0 = 1\cdot 22\, H\left(\frac{e^2}{H^2 G}\right)^{3/2}\frac{Z^3}{A^2} = 1\cdot 41 \times 10^{-3}\frac{Z^3}{A^2}\odot .$$

As the mass increases, the radius at first increases and attains its maximum value R_0 when the mass is M_0, and then it decreases with increasing mass.

For $M>>M_0$ the radius is given by

$$R = \frac{\alpha_0 l_0}{\mu_0^{5/3}}\left(\frac{\odot}{M}\right)^{1/3} \sim \frac{2\cdot 79 \times 10^9}{\mu_0^{5/3}}\left(\frac{\odot}{M}\right)^{1/3} \text{ cm.}$$

The radius increases as M decreases. The fact that the theory predicts for μ the value μ_0 *shows that for configurations of mass $M>>M_0$—and the known white dwarfs satisfy this condition—the stellar material is completely ionized.* In the usual white dwarf theory this is taken as an assumption ; here it follows naturally from the theory. The second case of $M<<M_0$ corresponds (in general) to planetary masses. A larger mass in this case is associated with a larger radius. The degree of ionization rapidly decreases with decreasing mass. For $M>M_0$ gravitational energy predominates over the electrostatic energy, whereas for $M<M_0$ the opposite is the case.

The mass-radius relation involves the chemical composition of the material, and in the figure the relationship is exhibited under the following alternative assumptions. The material is assumed to be (1) hydrogen, (2) helium and (3) iron. These assumptions will be referred to respectively as assumptions H, He and Fe.

In the case of iron two further alternatives are possible depending on whether for ρ^*, the density corresponding to single ionization, we take the theoretical value or identify it with the density of the ordinary metal (7·9 gm./cm.^{3}). The first alternative we shall denote by Fe (a) and the second by Fe (b). The various curves in Fig. I represent the theoretical mass-radius relation on the different assumptions.

As already mentioned when the mass M is not small compared to the Chandrasekhar critical-mass, the non-relativistic approximation breaks down and the relativistic theory has to be used. The dotted curves in the figure are based on Chandrasekhar's results. Each dotted curve merges in the corresponding non-relativistic curve in the region of M comparable to, or smaller than, $\odot$ as the relativistic effect is then negligible.

In the region of $M >> M_0$ the iron and the helium curves run very close together, for, in the case of completely ionized material μ_0 is (practically) the same for all elements except H and He[3].

It is now time that we compared the theory with observation. The observed mass-radius values for the white dwarf stars and the planets are all shown in the figure, and it is indeed interesting to find that the observed values fall in between the theoretical curves for hydrogen and iron respectively. The 'observed curve' by which we mean a smooth curve passing through (or as near as possible to) the observed (M, R) values is not drawn in the figure, but its general run is evident. It lies between the extreme theoretical curves. The values for the maximum

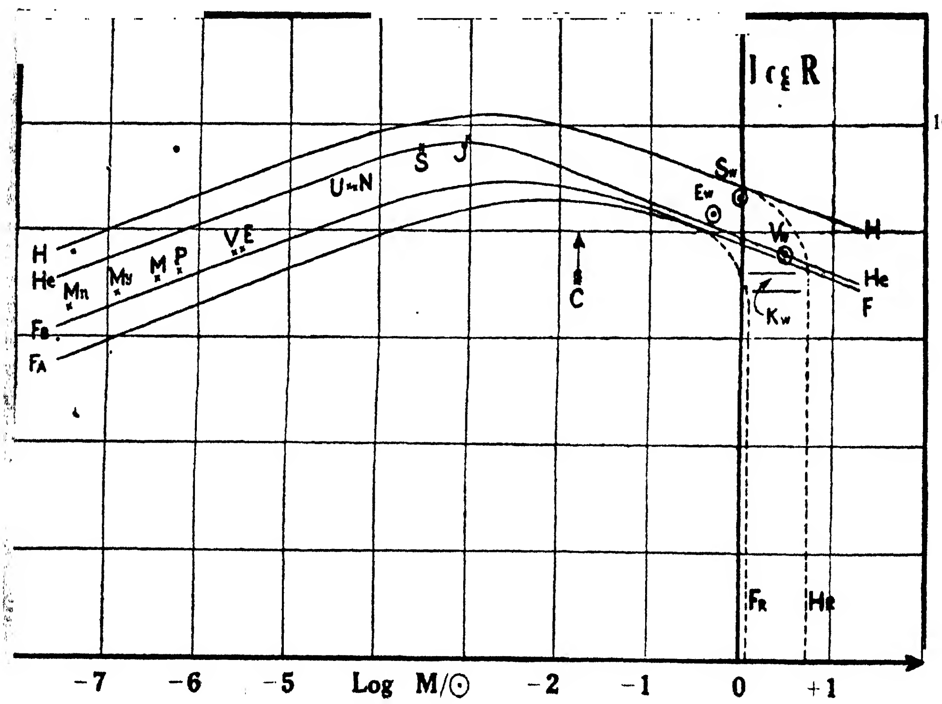

FIG. 1. The curves show the theoretical relation between mass M and radius R. (R is in cm., ⊙ = mass of the Sun). The curve HH and its modification HH_R due to the effect of relativity are for hydrogen. The curve HeHe is for helium. The curves F_BF and F_AF, and their modified forms F_BF_R and F_AF_R are for iron—the suffix A stands for the assumption Fe(a) and B for the assumption Fe(b).

M_n = Moon.	J = Jupiter.	C = Planet of 61 Cygni.
M_y = Mercury.	S = Saturn.	E_w = O_2 Eridani B.
V = Venus.	U = Uranus.	S_w = Sirius B.
E = Earth.	N = Neptune.	K_w = A.C. 70°8247.
M = Mars.	P = Pluto.	V_w = Van Maanen's star.

For K_w (the smallest white dwarf observed) the mass is not known. Its radius as estimated by Kuiper lies between the two horizontal lines indicated in the figure.

radius and the corresponding mass M_0, as estimated from the observed curve, are given in the following table which also includes for comparison the theoretical values.

		$R_0 \times 10^{-9}$ cm.	$(M_0/\odot)10^3$
From 'observed curve' ...		8	1·6
Theoretical :	Assumption H	12·5	1·41
	Assumption He.	4·94	0·70
	Assumption F_e(a)	2·77	2·79
	Assumption F_e(b)	1·96	7·92

(The radius of Jupiter, the largest planet, is $7{\cdot}0 \times 10^9$ cm.)

The maximum radius for a *cold* body predicted by the theory is about the same as the radius of the planet Jupiter. *There cannot be a 'cold body' (planet or white dwarf) larger in size than Jupiter.*

It will be noticed in the figure that the observed (M, R) values for the two heaviest planets Jupiter and Saturn lie much closer to the hydrogen curve than to the iron curves, whereas the terrestrial planets (Mercury, Venus, Earth, Mars) lie nearer to the iron curves than to the hydrogen curve. We are thus led to infer that the interiors of the outer planets Jupiter and Saturn are probably composed of *metallic hydrogen* (and possibly *metallic helium*), whereas the terrestrial planets possess much denser metallic cores.

It is interesting to observe that for the newly discovered planet (mass $0{\cdot}016\odot$) of the star 61 Cygni, the theory gives a radius of $3{\cdot}1 \times 10^9$ cm. or $9{\cdot}2 \times 10^9$ cm. depending on whether we assume it to be composed entirely of helium or hydrogen.

At this stage we are inclined to conclude that the comparison between theory and observation as depicted in Fig. 1 is reasonably satisfactory, but there is one aspect of it which is somewhat disconcerting. Our theory was intended to apply to *cold* bodies (or black dwarfs, a term originally due to Fowler) and strictly to bodies at the absolute zero of temperature, but we have compared it with luminous bodies, the white dwarfs ; and it may also (perhaps) be repugnant to some that white dwarfs and planets have been brought together in the same figure. We shall, therefore, consider the following two questions :—

(1) Is the theory of *cold* bodies applicable to white dwarfs? The defining characteristic of a white dwarf is its abnormally large mean density, say, exceeding 10^4 gm./cm.^{3} for a star of mass comparable to the Sun.

(2) Is the theory of *cold* bodies applicable to planets?

It is difficult to define a planet exactly but we all know something as to what it means, and for the moment we leave it at that.

It is (perhaps) easy to see from general considerations that the small luminosity of a white dwarf would have little effect on its radius, but to provide a quantitative answer and also to gain some insight regarding the conditions existing in actual white dwarfs a detailed study has been made of a 'model white dwarf', (mass $0{\cdot}5\odot$). The model consists of a non-relativistic degenerate core of radius a surrounded by a non-degenerate envelope ; the rate of energy generation is assumed to be uniform and equal to L/M per gram throughout the system, and further, the variations of opacity inside the non-degenerate envelope and thermal conductivity inside the degenerate core are ignored. The formal theory of such two-phase configurations has been given by Milne. *It is to be*

noted that the outward flow of heat in a star is mainly conductive when the matter is degenerate and radiative when it is non-degenerate. Thus for non-degenerate matter, it is opacity which is important, whereas for degenerate matter it is thermal conductivity which is significant. Degenerate matter is more opaque (less transparent) and more conducting than non-degenerate matter at the same temperature. It may be mentioned in passing that for degenerate matter radiation pressure must be negligible compared to the gas pressure, whereas for non-degenerate matter the ratio of radiation to gas pressure is unrestricted.

We return to our model star of mass $0 \cdot 5\odot$, and let us commence with its configuration which is wholly composed of a perfect (classical) gas. A well known result of Eddington's classic theory of perfect gas configurations gives for the temperature at the centre the value (for $M = 0 \cdot 5\odot$) $\frac{0 \cdot 68 \times 10^{18}}{R} \mu_0$ degrees. When the radius R is very large, the central temperature will be comparatively low, the energy generation due to nuclear transformations will be negligible, and the star will be dependent on gravitational contraction to supply the energy it radiates to space. As the contraction proceeds, the rising central temperature will at last rouse from their slumber the nuclear processes—from their state of hibernation they spring forth into life. But this life is death for hydrogen. Hydrogen is converted into helium and the sub-atomic energy so released supplies the star's expenditure of energy. This continues for a pretty long while, but ultimately the celestial fuel will be exhausted and the star again will have to fall back on gravitational contraction to meet its energy expenditure. The radius decreases, the central temperature increases but the density increases still more, and at last a degenerate core makes its appearance. This happens when the radius of the configuration is

$$R = 6 \cdot 9 \times 10^{9} \frac{1}{\mu_0^{5/3}\beta} \left(\frac{\odot}{M}\right)^{1/3} \text{cm.},$$

where β is given by Eddington's quartic equation,

$$1 - \beta = 3 \cdot 1 \times 10^{-3} \mu_0^{4} \left(\frac{M}{\odot}\right)^{2} \beta^{4}.$$

The star at this time is more luminous than it ever was or will be during its entire career, and the same is true for its temperature. In fact, with the birth of the degenerate core the star has reached the climax of its career. It enters the white dwarf stage which is a period (of order 10^{9} years) of gradual decline in luminosity, in effective temperature, and in radius which decreases by a factor of about 3. At the beginning of its white dwarf life, it is a 'blue (white) dwarf'—a term originally due to Eddington—about 10^{3} times more luminous than the Sun and having an effective temperature of $1 \cdot 7 \times 10^{5}$ degrees and a mean density of $1 \cdot 1 \times 10^{4}$ gm./cm.^{3}. As the degenerate core gradually increases in size, the blue dwarf changes into a 'white' (white) dwarf (it is usual to drop the first 'white') then, a yellow (white) dwarf, a red (white) dwarf, till finally it ends as a black dwarf (a white dwarf of zero luminosity). A 'blue dwarf' has been recently observed: Minkowski has made the interesting discovery that the star of 1054 A.D. in Crab Nebula has the usual size of a white dwarf but its luminosity is $2 \cdot 5 \times 10^{4}$ that of the Sun and its effective temperature about 5×10^{5} degrees. Several 'white' dwarfs are known but the yellow, red and obviously black will be too faint

to be accessible to direct observation. The usual white dwarfs possess a luminosity-mass ratio of the order of 10^{-2} ergs per gram per second, and adopting for our model white dwarf (mass $0 \cdot 5 \odot$) a luminosity of 10^{31} erg/sec., we find that the effect of its small luminosity is merely to increase its radius by about 3 per cent above the value it would have if it were a black dwarf.

The important derived properties of the model white dwarf are tabulated below :—

Data given : $M = 0{\cdot}5\ \odot$, $L = 10^{31}$ erg/sec., $\mu_0 = 2$.

Derived properties :

$$\frac{\text{Thickness of gaseous envelope}}{\text{Radius of the star}} = 0{\cdot}034,$$

Radius $= 1{\cdot}14 \times 10^9$ cm.,
Mean density $= 2{\cdot}81 \times 10^5$ gm./cm.^{3},
Effective temperature $= 10200$ degrees,
Central temperature $= 1{\cdot}37 \times 10^7$ degrees,

$$\frac{\text{Flow of heat by conduction}}{\text{Flow of heat by radiation}} = 2{\cdot}05 \times 10^5 \text{ (at the centre).}$$

We have just mentioned that a star is likely to reach the white dwarf stage when its hydrogen supply has been almost exhausted. The hypothesis that hydrogen is practically non-existent in the interior of a white dwarf is supported by another argument which is much more compelling (see also page 12). As the protons obey Fermi-Dirac statistics, their average kinetic energy can never be less than the Fermi-Dirac residual or null-point energy ; and, as the latter depends only on the concentration of the protons, for any given proton concentration we can determine the minimum value ε_0 of the rate of energy evolution due to the proton-proton reaction (the rate of other nuclear reactions will be so negligible that they can be disregarded).

Proton + Proton⟶Deuteron + Positron.

This minimum value for energy generation (the basal katabolic rate) increases extremely rapidly with proton concentration, and therefore, even for completely degenerate matter, provided the concentration of protons is sufficiently high, the rate of energy evolution will reach an excessively high value.

In case the protons can be regarded as arranged in a lattice (*e.g.*, metallic hydrogen), it is much more accurate to approach the problem of energy generation from the point of view of the residual energy of the (protonic) oscillators—this gives for ε_0 a much larger value than the former method. Without entering into details we may state the general result that if an appreciable amount of hydrogen were present in a white dwarf, its predicted luminosity would be of an order far higher than the observed one (the discrepancy would be greater as the mass of the star is larger). When the density of hydrogen is 10^6 gm./cm.^{3}, the value of ε_0 si 3×10^3 erg/gm.-sec. and if the density is reduced by a factor of ten, the energy generation is $0{\cdot}1$ erg/gm.-sec. . It is even now more than ten times larger than the observed value for Sirius B. We are thus led to regard that in a white dwarf the proportion of non-hydrogen elements would be far in excess of hydrogen and the value of μ_0, the mean molecular weight per free electron, must therefore be taken as 2.

After this somewhat long description, our conclusion is fairly simple. The observed (M, R) values for white dwarfs ought to lie on the theoretical curve for black dwarfs corresponding to $\mu_0 = 2$ (non-hydrogen), unless the

white dwarf is excessively hot and luminous, that is, it is a blue dwarf, in which case its radius may be a few times larger than the corresponding black dwarf radius. The (M, R) values for ordinary stars (not white dwarfs) must be far above the theoretical curve. No observed (M, R) values for stars ought to lie below the theoretical curve for $\mu_0 = 2$,—the region in the mass-radius diagram below the theoretical curve is forbidden for the stars. A glance at the figure shows that whereas the other white dwarfs fall almost on the non-hydrogen curve, Sirius B, the best (most accurately) known of them, contradicts the theory by falling very near the hydrogen curve. The calculated radius for $\mu_0 = 2$ is smaller than the observed value by a factor somewhat larger than 2. I do not know what penalty Sirius *B* will have to pay by proving a delinquent—it may have to go into the class of close-binaries—but I trust we have not been unjust in demanding that a white dwarf should lie on the non-hydrogen curve for black dwarfs.

We now come to the planets. A planet may be defined as a body which is not self-luminous and which in mass is much smaller than a star. The first condition requires that the surface temperature should not exceed about 700°K, but it is difficult to express the second condition precisely. In the absence of a satisfactory theory of the formation of planetary systems, it is difficult to fix with any pretence to accuracy the upper limit to the mass of a planet—it seems true that we cannot define a planet because we have no theory for it. We can do no better, therefore, than put the upper limit to the mass of a planet at 0·01 $\odot$ roughly.

In the case of a planet, because of its small mass, the central temperature and density will never be high enough for the subatomic reactions to occur and, therefore, unlike the case of a star, the relative abundance of the elements in a planet will remain unchanged except for a possible loss of light elements, chiefly hydrogen and helium, which because of the comparatively high velocities of their atoms may escape from the planetary surface. A planet is a sample of stellar (or may be pre-stellar!) material bottled up a few thousand million years ago and placed in cold storage so that no nuclear reactions disturb the initial elemental composition. The loss of hydrogen and helium, however, is negligible for the heavier planets and will be very serious only for lighter planets like the earth ; and we expect the relative abundance of hydrogen and helium to be far greater in heavy than in light planets. Further, as the degree of ionization in degenerate matter depends on pressure, the ionization will change with the decrease in the planetary mass. But must a planet be composed of degenerate matter?

Consider a planet of mass 0·01 $\odot$ and, for the sake of illustration, assume it to be all hydrogen. Let us start with a configuration which is composed of a *classical* gas, then, as the radius decreases the central (and also the surface) temperature increases, but the density increases all the more, and ultimately when the radius is of the order of 10^{11} cm., a degenerate core makes its first appearance. It is difficult to determine this value accurately as the theory of two phase configurations incorporating pressure ionization has not been worked out. What the surface temperature then will be, it is very difficult to estimate, but a crude order-of-magnitude calculation shows that it will not be much different from 10^3 degrees K. For planets of smaller mass, the temperature will be still lower. As the core increases in size the central and the surface temperature will fall till, when the core has completely swallowed the planet, the entire mass will be reduced to zero temperature, and possess a radius $1{\cdot}0 \times 10^{10}$ cm.. Thus, as in the case of a white dwarf, the radius of the configuration in which degeneracy just sets in is a

few times larger than the completely degenerate configuration. The planet has a great freedom with regard to its size. The lower limit for its radius is fixed at $1{\cdot}0 \times 10^{10}$ cm., but there is no upper limit save that it should not be so large as to make the configuration unstable against the tidal action of the star to which it belongs.

We may describe the above situation in somewhat different terms. Suppose we are interested in only those configurations of the planet for which the upper limit (T_0) to the surface temperature is much below 10^3 degrees K. Then, the radius will be either very near its lower limit r_0, or will be above a certain value r_1, the range from r_0 to r_1 being forbidden —for R lying between r_0 and r_1, the surface temperature will exceed the limit set for it. The 'forbidden range' widens with decreasing T_0, till, when T_0 is sufficiently low, the upper limit r_1 will go beyond the bound of stability against tidal action, and the only permissible radius for the planet will be (almost) r_0.

For a planet whose surface is warm—we are concerned here with the surface temperature as determined by the planet's own internal heat and not that which is sustained by the radiation from the Primary—the radius may possibly be several times bigger than the value given by the theoretical mass-radius relation for completely degenerate bodies. But when the surface is intensely cold, as is the case with the planets in our own system, the observed (M, R) values should agree with theory. And, it is right to add here that for light planets ($M << M_0$), the ionization becomes so feeble (in fact μ begins to exceed A) that as already remarked the theory of pressure ionization, because of the various simplifying assumptions on which it is based, begins to break down. However, in the region of M comparable M_0, the theory is not unsatisfactory, and the estimate for the maximum radius of a cold body (white dwarf or planet) can be regarded as fairly accurate.

I think we have borne with cold matter for too long a while and I close with the fain hope that dense matter is not a dunce matter.

SECTION OF CHEMISTRY

President :—R. C. RAY, D.Sc., F.I.C.

SOME ASPECTS OF MODERN INORGANIC CHEMISTRY

(*Delivered on Jan. 6, 1944*)

INTRODUCTION

I had the honour of attending the first meeting of the Indian Science Congress which was held in Calcutta in 1914. Sir Prafulla Chandra Rây was the President of the Section of Chemistry on that occasion, and I shall never forget the interest and pleasure I felt in listening to the Address of that great master of science and the father of chemical research in this country. Little did I dream then that in 1944 I should have the honour and privilege of occupying the chair of the Chemistry Section. I appreciate the honour highly and wish to record my thanks to the Committee of the Indian Science Congress Association for electing me President of this Section. A position of honour, however, brings with it many responsibilities, and I thank you all for your help and co-operation which have brought the present session to a successful conclusion.

It has become customary for the President to select for his Address a topic regarding which he has carried out some investigations or to survey the field of research in which he is personally interested. Following this time-honoured practice, I wish to speak to you to-day on "Some aspects of modern Inorganic Chemistry." Limits of time and space, however, forbid me to attempt any comprehensive review of all recent work in this branch of chemistry. As it is impossible to do more than refer to a very few of these, it is with great regret that many interesting investigations are of necessity left out. Although it may seem invidious, the choice of topics is bound to be a question of personal preferences.

Towards the close of the nineteenth century, inorganic chemistry was at its lowest ebb, mainly because of the very rapid development of organic chemistry and the rise of physical chemistry. The good behaviour of the carbon atom, with its four stable valencies, its willingness "to combine with itself indefinitely without affecting the stability of the molecule", the ease with which a multiplicity of definite new compounds can be prepared, and the application of many of these compounds in the dyestuff and other industries contributed to draw a large number of chemists to undertake researches on carbon compounds. When Ostwald succeeded Kolbe at Leipzig in 1887, a new field of chemistry opened—that of physical chemistry. Research problems were offered in abundance, and chemists everywhere were not slow to take them up. Physical and organic chemistry thus came to dominate the field, and inorganic chemistry was gradually pushed into the background. Comparatively few chemists were left who had the courage and perseverance enough to find out adequate methods of analysis and purification of materials so necessary for inorganic work.

There are many who think that there is now no future for inorganic chemistry, except in its application to industry. It is generally assumed

that inorganic chemistry has progressed as far as it could with the tools at hand. The discovery of the inert gases of the atmosphere by Ramsay and his co-workers and practically all the missing elements seems to have added the last chapter to inorganic chemistry ; and one may really wonder what is there left to be done. The accumulated treasures, no doubt, seem marvellous, but as each year rolls by we find ourselves, like Balboa, looking down from the mountain top, beholding an infinite and beautiful expanse, yet unfathomed. We feel with Newton like children gathering shells on the shores of an infinite sea. The vista continues to widen, and new problems, new theories, new viewpoints loom large before us with kaleidoscopic diversity. To quote Priestley : "In completing one discovery we never fail to get an imperfect knowledge of others of which we could have no idea before, so that we cannot solve one doubt without creating new ones". When you throw wood on an open fire in the night you expand the lighted area, but you also extend the circle of the surrounding darkness. So it is with all branches of science ; with each increase in knowledge, a larger circle of surrounding ignorance is disclosed. It seems that "the unfinished window in Aladdin's tower, unfinished must remain".

Compounds of the Inert Gases

When the inert gases were first isolated from the atmosphere and it was found that none of them could be made to combine with other elements, it seemed that these elements would always remain chemical curiosities. In course of time, however, they have not only received industrial application and neon lights are blazing forth their messages in all the cities of the world, but they have been of the greatest importance to chemical theory. The electronic arrangement in the atoms of these elements is of the stable types to which other atoms tend to approach. When atoms combine to form molecules, the atoms usually acquire electronic structures on the same plan as the inert gases. The valency of these elements was supposed to be zero, and they fall into line very well in Group O of the Periodic Table. The possibility of compound formation was first suggested by the work of Villard[1] soon after the discovery of these gases. He found that when a mixture of water and the inert gases, argon, krypton or xenon, was cooled under pressure, crystalline hydrates were formed. Villard's experiments were repeated and extended by de Forcrand[2]. The dissociation pressures were found to be high at 0°, except for xenon which forms the most stable hydrate having a dissociation pressure of 1·4 atmospheres at $1{\cdot}4^\circ$. The heats of formation of the solid hydrates from gas and liquid water were measured. The values obtained were 14,885, 14,712 and nearly 17,000 cals. for argon, krypton and xenon respectively. If the number of water molecules combined with one atom of the inert gas is calculated from these values, it comes out as 5·5 for argon, 5 for krypton and 6-7 for xenon. Considering the experimental difficulties and the question of symmetry of the molecule, it is likely that the number of molecules of water is the same for all the hydrates, and each inert gas atom is surrounded by six molecules of water. The structure of the hydrates would then be similar to the co-ordination compounds of the cobaltammine type. The formation of hexahydrate is supported by the recent work of Nikitin[3] who obtained the hydrates $Ne.\ 6H_2O$ and $A.\ 6H_2O$. He has shown that the inert gases have many analogies in the formation of co-ordination compounds. The crystallohydrates of the inert gases are not only similar in composition

and structure with corresponding crystallohydrates but they also form mixed crystals with the latter.

The interest in the compounds of the inert gases has been revived in recent years by the work of Booth and Willson[4]. From a study of the system, boron-trifluoride-argon, they found that the freezing point of any mixture increases with increase in pressure up to a certain value and was not affected by any further increase in pressure, indicating an equilibrium :

$$A + x\ BF_3 \rightleftharpoons A.\ x\ BF_3$$
$$\text{or } A.\ x\ BF_3 + y\ BF_3 \rightleftharpoons A.\ (x+y)BF_3$$

The freezing-point-composition curves exhibited maxima and minima, the maxima corresponding to the ratios A. BF_3, A. $2BF_3$, A. $3BF_3$, A. $6BF_3$, A. $8BF_3$ and A. $16BF_3$ indicating compound formation. These compounds are unstable and dissociate above their melting points. From the shape of the curve the compound A. $2BF_3$ appears to be the most stable. It is curious that this is so and that A. $4BF_3$ is not formed. Presumably, in these compounds, the inert gas is acting as a donor of electrons and the BF_3 molecule accepts an electron pair as in the co-ordination compound $NH_3 \rightarrow BF_3$ or $H_2S \rightarrow BF_3$. This would account for the compounds in which the ratio of A : BF_3 is 1 : 1, 1 : 2 or 1 : 3. In the higher members, BF_3 molecules are probably linked through fluorine atoms. Booth and Willson state that at pressures between 5 and 10 atmospheres, liquid BF_3 becomes viscous and is probably associated. The compound A.$6BF_3$ may be represented $(F_3B \leftarrow F_3B)_3A$, that is, a fluorine atom of the BF_3 molecule attached to the argon atom acts as a donor of two electrons to a second BF_3molecule, and the higher members may be constituted in the same manner. The formation of co-ordination compounds of the inert gases opens up an interesting field of research, and a considerable amount of work still remains to be done in this direction. It is likely that compounds with xenon would be much more stable, and besides H_2O and BF_3, co-ordination with other donor or acceptor molecules may be tried. In fact, during the last few years complex compounds of the inert gases with phenol have been prepared. By analogy with substances of roughly similar physical properties, such as hydrogen sulphide which forms an addition compound with phenol, the inert gases could be expected to form similar addition compounds. Nikitin[5] obtained the compounds $Rn.2C_6H_5OH$ and $Xe.2C_6H_5OH$. The compound, $Xe.2C_6H_5OH$ was found to be about one-third as stable as $H_2S.2C_6H_5OH$. The dissociation pressures of $Xe.2C_6H_6H_5OH$ and $HCl.2C_6H_5OH$ approach each other closely at corresponding temperatures. The isomorphism of $Xe.2C_6H_5OH$ and $HCl.2C_6H_5OH$ was also established. The evidence of formation of a compound of krypton with phenol could be obtained only qualitatively.

It would appear from theoretical considerations that co-ordination compounds of the inert gases of higher atomic weights are not fortuitous, and the rule of zero valency cannot be rigidly true. In the first place, all the inert gases have not the maximum number of electrons on their outer orbits. Since the maximum number of electrons possible in a quantum group of n is $2n^2$, it is evident that the third and the higher groups in argon, krypton, xenon and radon are capable of expansion so that they might be expected to act as acceptors of electrons. Secondly, if the view that molecules co-ordinate by giving electrons to an acceptor is regarded as correct, there is no reason why the inert gases should not also act as donors of electrons. If on the other hand, it is assumed that co-ordination takes place by the attraction of a molecule with a dipole

moment to a central ion, the possibility of the union of an ion with the inert gas atoms seems more remote. Even on this view of co-ordination, however, there is the likelihood that under suitable conditions a central ion may polarize by induction an inert gas atom sufficiently to form a compound. Naturally such compounds would be unstable at ordinary temperatures, but there are no grounds for supposing that they are not true chemical compounds.

Helium does not form co-ordination compounds of the types mentioned. This is to be expected, because of its small size and polarizability, and stability of structure in the ground state. The helium atom may, however, become excited to a higher level by the absorption of 19·75 electron-volts, and one electron is then promoted to the second quantum level. In this state, the atom has some resemblance to hydrogen, and compound formation takes place. The diatomic molecules He_2 and HeH, which are formed in discharge tubes and so well-known to spectroscopists, are familiar examples, but, of course, they cannot be prepared in bulk. It is natural to expect that the excited helium atom would readily combine with the halogens, but so far no such compound has been reported, probably on account of the experimental difficulties involved. Helides of some elements have, however, been obtained in weighable quantities. Manley[6] found that helium is capable of combining with mercury in the presence of electric glow discharge at low pressure. Very careful experiments in which the greatest care was taken to ensure the purity of all materials used showed that a gaseous mercury helide was formed. The helide is stable below red-heat and does not give the emission spectrum of mercury until it is decomposed. The compound is not condensed at the temperature of liquid air and is rapidly decomposed into its constituents by the action of ultra-violet light. The helide was analysed by passing the gas over a glowing platinum wire and the mercury formed by decomposition was condensed and weighed. Conflicting results were obtained : at first the formula was reported to be $HgHe_{10}$, but later results, obtained by using a new apparatus for the synthesis of the compound and Aston's microbalance for determining density, corresponded with the formula HgHe, which is more probably $HgHe_2$, the analytical ratio differing only slightly from HgHe. It is also possible that both $HgHe_{10}$, and $HgHe_2$ exist, different compounds being formed under different conditions.

In 1925, Boomer[7] obtained a solid compound of tungsten and helium. When a tungsten filament was made to glow in a discharge tube which contained helium, a black deposit was formed. The deposit was collected and weighed. The weight of combined helium was calculated from the change of pressure and it agreed with the formula WHe_2. The properties of the compound are different from those of tungsten. It was shown that when the compound is treated with 20% nitric acid or potassium hydroxide solution, the helium was rapidly evolved and any excess of tungsten above that required for the formula WHe_2 remained undissolved. That the combination of helium with tungsten was not noticed earlier is probably due to the fact that the formation of the compound is extremely sensitive to the conditions of the experiment, the best result being obtained at a pressure of 0·1 to 0·45 mm., using a current of 5 to 10 milliamps at 1000 volts. Under these conditions 5 c.mm. of helium at N.T.P. combine per minute. Traces of mercury vapour catalyze the velocity of the reaction.

The preparation of several other helides has been reported. It has been found that the excited helium atom can combine with the vapour of

mercury, iodine, sulphur and phosphorus. Damianovich[8] and his co-workers have carried out a considerable amount of work on these compounds which are all condensable in liquid air. When the condensate is warmed up, the helium is suddenly liberated at temperatures far below the freezing point of the vapours of elements themselves, so that it is improbable that the helium is merely occluded. It may be pointed out that the later work in the case of mercury does not agree with that of Manley who states that the mercury helide is not condensed at the temperature of liquid air. Damianovich has also studied a similar compound of platinum. When a discharge is passed through helium at a low pressure, using platinum electrodes, a platinum helide is produced. Like tungsten helide, platinum helide is also a solid which dissolves in dilute aqua regia, the rate of dissolution increasing with the amount of helium present. X-ray studies indicate the probability of the presence of a compound. The density of the helide is naturally less than that of platinum, and the helide is decomposed into its elements at 380°C. It appears that the helide has some properties in common with platinum hydride, but it seems to be a more definite compound.

From what has already been said, it is clear that a considerable amount of work still remains to be done in this direction. Although up to the present the evidence is negative, the possibility exists that other inert gases may also form compounds after excitation. From considerations of ionic radii Pauling[9] has predicted the formation of XeF_6 and KrF_6 and the unstable XeF_8. The possibility also arises that some of the inert gases may also combine with other halogen elements. Antropoff, Weil and Frauenhof[10] thought that they had obtained a krypton chloride by passing an electric discharge through krypton and chlorine and condensing in liquid air, but later work by Antropoff, Weil and Krüger[11] showed that nitric oxide had been formed by traces of air, and hydrochloric acid had been formed by the grease. The compound between nitric oxide and hydrochloric acid, which is red, was at first thought to be krypton chloride. This shows the necessity of ensuring the purity of materials used, and avoiding extraneous matter. The work on the compounds of inert gases requires a special technique and the greatest care in the purification of the materials used.

Developments in the Chemistry of Boron

During the last thirty years considerable progress has been made in the chemistry of boron and its compounds. It has been shown[12] that the substance which was long regarded as amorphous boron is not pure. It always contains varying amounts of oxygen and appears to be a solid solution of a lower oxide of boron in elementary boron. When amorphous boron is heated to red-heat, the element volatilizes and condenses on the cooler parts in the crystalline form. Crystalline boron is hard and black and is insoluble in nitric acid, while the so-called amorphous boron is a maroon-red unctuous powder which readily dissolves in nitric acid.

Since the isolation of tetra-borane by Stock and Massenz[13] in 1912 the hydrides of boron have attracted considerable attention and interest on account of their unusual chemical properties, and their importance in elucidating the nature of the chemical bond and valency. The existence of the boron hydrides has been known for a long time, but they are so unstable and react with moisture and air so readily that very little progress was made in their investigation until Stock developed a special technique in the study of such compounds. Six hydrides of boron are now known:

(1) diborane, B_2H_6 (b.p.—92·5°C) ; (2) tetraborane, B_4H_{10} (b.p. 18°C), (3) stable pentaborane, B_5H_9 (b.p. 40°C) ; (4) unstable pentaborane, B_5H_{11} (b.p. 63°C) ; (5) hexaborane, B_6H_{10} (m.p.—65°C) and (6) decaborane, $B_{10}H_{14}$ (m.p. 99·7°C). All the hydrides were isolated by Stock and his co-workers, except the unstable pentaborane which was discovered by Burg and Schlesinger[14]. The early history of the hydrides and the knowledge gained about them up to 1932 as well as the special technique developed by him were reviewed by Stock in his Baker Lectures[15] at Cornell University. It seemed then that the work was nearly complete, but during the last decade, Schlesinger and his school have advanced our knowledge about these highly unstable and greatly reactive substances.

In 1931, Schlesinger and Burg[16] developed an entirely new method for preparation of boron hydrides. It consists essentially of the hydrogenation of boron chloride or bromide by means of powerful electric discharge. With the development of this ingenious method, fairly large quantities of diborane could be prepared and its reactions with other substances studied. All the recent researches have been carefully surveyed by Schlesinger and Burg[17], and I shall content myself with briefly referring to two very interesting types of compound, namely borine carbonyl and the metallo-borohydrides. Borine carbonyl[18] was prepared by the action of diborane with a large excess of carbon monoxide in a sealed tube at 100°C and high pressure. The equilibrium, $2CO + B_2H_6 \rightleftharpoons 2H_3BCO$, which is quickly attained, is fixed by chilling. The three components of the mixture could be isolated by fractional condensation. Borine carbonyl melts at $-137·0$°C and decomposes at the room temperature into diborane and carbon monoxide. The addition of an equal volume of carbon monoxide to pure borine carbonyl, however, almost completely prevents the decomposition of the latter. This fact has been explained by the assumption that the first stage of the decomposition, $H_3BCO \rightleftharpoons CO + BH_3$ is rapid and reversible, but the second stage $2\ BH_3 \rightleftharpoons B_2H_6$ is irreversible. A high concentration of carbon monoxide would greatly reduce the concentration of borine (BH_3), so that the rate of reaction of the second stage would considerably decrease, especially as the irreversible reaction appears to be a reaction of second order with respect to borine. Borine carbonyl is somewhat similar to volatile metal carbonyls[19]. Like them, it is more volatile than hydrocarbons of similar molecular weight, and reacts with tertiary amines with displacement of carbon monoxide :

$$H_3BCO + (CH_3)_3N \longrightarrow CO + H_3B.N(CH_3)_3.$$

Borine carbonyl, however, differs sharply from the hydrogen metal carbonyls.

One of the most striking results of recent researches on the reactions of diborane is the discovery of the metallo-borohydride. The borohydrides of lithium[20], beryllium[21] and aluminium[22] have been more fully investigated. They have been prepared by the action of diborane on alkyl compounds of the corresponding metals, for example, lithium borohydride is obtained in almost pure state by the action of diborane on lithium ethyl at room temperature :

$$2LiC_2H_5 + 2B_2H_6 \longrightarrow 2LiBH_4 + (C_2H_5)_2\ B_2H_4$$

Lithium borohydride is a definitely salt-like substance and has been given the formula $Li^+BH_4^-$, but the beryllium borohydride BeB_2H_8 is a highly volatile solid, and aluminium borohydride $Al.B_3H_{12}$ is a still more volatile liquid. The gradation of properties from the relatively high

melting, non-volatile and polar lithium borohydride to the low-melting, highly volatile and almost non-polar aluminium borohydride is very striking ; while the properties of aluminium borohydride approach those of diborane itself, the properties of beryllium borohydride are intermediate between those of corresponding lithium and aluminium compounds.

About the time when Stock and his collaborators announced the isolation of the boron hydrides, Travers and Ray[23] were also working on the boron compounds. It is curious how different workers attack identical problems almost simultaneously, and how our knowledge of a particular subject develops from different sides. It seems that the time must be ripe for progress on a special line. Travers and Ray found that boron hydrides were readily decomposed by water, but when magnesium boride was treated with water, a strongly reducing solution was obtained with evolution of hydrogen containing traces of hydrides. The reducing solution appeared to contain a compound of the formula $H_6B_2O_2$. This preliminary work[23] was extended by Travers, Ray and Gupta[24]. It was shown that when magnesium boride was treated with water, three molecules of hydrogen were evolved for every molecule of Mg_3B_2. The solid residue which remained after magnesium boride had been repeatedly extracted with water was a white powder with which ammonia seemed to give the ammonium salt of a compound of the formula $H_{12}B_4O_6$. When $H_{12}B_4O_6$ was heated in a vacuum it lost five molecules of hydrogen resulting in the formation of $H_2B_4O_6$ which on further heating left a residue which had an approximate composition B_4O_5. The action of heat on the compound $H_6B_2O_2$ resulted in the formation of the oxide B_2O_2. Both these oxides were obtained in an impure state being contaminated with varying quantities of magnesium oxide.

The best method of preparing magnesium boride is by heating an intimate mixture of one part boric anhydride and 2·25 parts of magnesium powder at red heat in a stream of hydrogen. The reaction takes place with deflagration, but when the mixture does not deflagrate, the reaction is not complete and free boric acid is present. The mechanism of hydrolysis of magnesium boride has been studied[25]. It has been shown that the hydrolysis of magnesium boride at the room temperature takes essentially the same course whether it is effected by water or by dilute acid. The main product of hydrolysis is a substance $Mg_3B_2(OH)_6$. At a temperature slightly below $-10°C$, however, an entirely different product of the composition $H_3B_2(Mg.OH)_3$ which is readily converted by the action of water into $Mg_3B_2(OH)_6$ with liberation of hydrogen, especially when the temperature is slightly increased. The course of hydrolysis may be represented by the following equations :—

$$Mg_3B_2 + 3H_2O = H_3B_2(Mg.OH)_3$$
$$H_3B_2(Mg.OH)_3 + 3H_2O = Mg_3B_2(OH)_6 + 3H_2.$$

It is found that, contrary to what has been generally supposed, no boric acid or magnesium borate is formed in the hydrolysis of magnesium boride by water or dilute acids. The compound $H_3B_2(Mg.OH)_3$ finds its parallel in the compound $SiH_2(Mg.OH)_2$ isolated by Schwarz and Konrad[26] in the preparation of silane from magnesium silicide.

It has already been mentioned that Travers, Ray and Gupta showed that the aqueous extract obtained by the hydrolysis of magnesium boride contained the compound $H_6B_2O_2$. The compound exists in two isomeric forms which for convenience may be called $\alpha-H_6B_2O_2$ and $\beta-H_6B_2O_2$. The most important difference between the α- and the β-compound is that while each molecule of the former loses 4 atoms of hydrogen when

treated with an acid, the latter yields only 2 atoms of hydrogen per molecule by the action of an acid. One further molecule of hydrogen is removed from the α-compound by addition of iodine to the acidified solution, but 2 molecules of hydrogen are lost by the β-compound when similarly treated. The di-potassium salt of the α-compound was isolated[27] in 1922, and the di- and the tetra-potassium salts of β-$H_6B_2O_2$ were prepared[28] in 1937. All the compounds form colourless and well-defined crystals, and do not contain water. They all act as powerful reducing agents. Salts of silver, gold, etc. are reduced to metals, and with copper sulphate solutions a red precipitate of "copper hydride" is obtained. Both α- and β-$B_2H_4K_2O_2$ give with nickel sulphate a greenish precipitate which contains both nickel and boron. The salts, with the exception of β-$B_2H_4K_2O_2$, are fairly stable when preserved in a vacuum or in a vessel free from moisture and carbon dioxide. They are all completely oxidised by nitric acid. In the process of separating di- and tetra-potassium salts of β-$H_6B_2O_2$, a di-potassium salt of a compound of the formula $H_4B_2O_2$ which is obviously a decomposition product of the former or its isomeride has also been obtained[29].

The residue left after magnesium boride has been repeatedly extracted with water is a white powder. If this residue is treated with concentrated ammonia solution in an atmosphere of hydrogen, a reducing solution is obtained. By fractional crystallization of this solution in a vacuum, two compounds of the formulæ $(NH_4)_2B_2(OH)_2$ and $(NH_4)_2B_4O_6$ are obtained[30]. Both the compounds are crystalline and quite stable in contact with ammonia solution ; in the dry state they are stable below 0°C. Neither of the compounds liberates hydrogen with acids, but while the former does not react with barium, calcium or magnesium salts, the latter gives a white crystalline precipitate with each. The two lower oxides of boron, B_2O_2 and B_4O_5, and their corresponding acids $H_4B_2O_4$ and $H_2B_4O_6$, can be prepared respectively from these two compounds. The compound $(NH_4)_2B_2(OH)_2$ is analogous to β-$K_2B_2(OH)_2$[31] and $(NH_4)_2B_4O_6$ is analogous to $K_2B_4O_6$[32]. The attempts to isolate the 4-boron borohydrates of the formula, $H_{12}B_4O_6$ discovered by Travers, Ray and Gupta[33] have not yet been successful.

A few words should be said about the constitution of the isomeric borohydrates, α - and β-$H_6B_2O_2$. There is little doubt that the borohydrates are closely related to diborane, B_2H_6, and are probably derived from the latter. Although a large amount of investigations has centred round B_2H_6, no satisfactory structural formula has yet been assigned to it. The difficulty of giving an adequate explanation of the existence of many boron compounds, such as B_2H_6, which is in agreement with the Lewis-Langmuir theory of valency, and the concepts of octet and duplet, is due to well-known fact that the boron atom has only three valency electrons, whilst any structural formulæ which can be assigned to these compounds seem to require four valency electrons.

The mechanical concept associated with the Lewis-Langmuir theory has been applied so successfully to the treatment of problems of organic chemistry, in a general way, that the fact seems to be lost sight of that in a series such as,

$$B_2H_6 \qquad C_2H_6 \qquad N_2H_4 \qquad O_2H_2 \qquad F_2H_2$$

only a forced explanation is available to account for the compounds of elements of higher atomic weight than carbon, for which the ratio (valency electrons)/(chemical bonds) is increasingly greater than unity. Looking at the matter from this standpoint, it is not surprising that in

the case of boron, the ratio is less than unity. That this mechanical concept can be applied to a very large number of carbon compounds is no sound argument in its favour if it fails in the case of other elements[33a].

In discussing the problem of B_2H_6, Lewis[34] writes, "In order to account for the hydrides of boron . . . . Sidgwick proposed that two of the bonds between the boron and the hydrogen in B_2H_6 are single electron bonds. The suggestions have been amplified by Pauling[35], through the assumption that it is no particular bonds that permanently have this one electron character, but rather this character alternated among several bonds in a sort of resonance. . . . . I am inclined to write for B_2H_6 the same formula which we have written for ethane (the usual formula), indicating in some way that two electrons are missing, so that on the average each bonding pair of orbits is only occupied six-sevenths of the time. We shall thus have a picture of a molecule in which all the electrons remain paired." Either of these statements is equivalent to an admission that in these cases the theory breaks down completely, for there is no virtue in the fraction six-sevenths.

It is now generally admitted that any chemical bond is not the resultant of a pair of electrons, nor even of all the electrons associated with the pair of bonded atoms, but of all the electronic forces in the molecule[36]. In the case of carbon compounds it is possible to accept this view and still to retain the idea that chemical bonds are closely related to paired electron orbits. Being at the centre of the Periodic Table, carbon is exceptional in this respect. In order to illustrate the relationship between boron compounds and carbon compounds a few further general remarks must be made. The relationship between B_2H_6 and C_2H_6 is supported by the fact that B_2H_6 reacts with HCl or HI to yield a compound B_2H_5Cl or B_2H_5I which suggests the existence of an intermediate B_2H_4. The reaction of the compound α-$B_2H_6O_2$ with acid simply involves catalysis of reversible processes:

$$H_6B_2O_2 \rightleftharpoons H_2 + H_4B_2O_2$$
$$H_4B_2O_2 \rightleftharpoons H_2 + H_2B_2O_2.$$

Parallels are to be found in the formation of ethylene from ethane and acetylene from ethylene. That hydrogen can be replaced in B_2H_6 by (CH_3) to the extent of four atoms but that $B_2(CH_3)_6$ does not exist but only $B(CH_3)_3$ will probably find a parallel in the case of the dissociation of $C_2(Ph)_6$. The relationship is well worth careful study, for it may throw light on the later process, in which the apparent weakness of the C-C bond is associated with the resonance energy of the $C(Ph)_3$ radical. $B(CH_3)_3$ has not apparently the properties of a radical.

Wiberg[37] and his associates call attention to the analogies between diborane and ethylene. The observed value of the parachor was found to be 121·9, which agrees with the calculated value 121·2, made up of the values for two B atoms ($2 \times 16{\cdot}4$), four H atoms ($4 \times 17{\cdot}1$), one double bond (23·2), and two electro-valencies ($-2 \times 1{\cdot}6$). The constitutional similarity between diborane and ethylene is also brought out by the fact[38] (Hausser, unpublished) that the ultraviolet absorption spectra of both compounds show bands in the region 185-210$\mu\mu$, where none are observed in the case of ethane.

The analogous behaviour of diborane and ethylene points to a similarity in their electronic structures, and this idea may be extended to show that hydroborons and borohydrates are by no means unique. Diborane itself, and the isomeric compound $B_2H_6O_2$ yield stable ions, of which the

electronic structure must be similar to that of $[BF_4]^-$ ion, and also to the stable compounds containing the structures :

$$\left[\cdot\dot{\underset{\cdot}{B}}\cdot\right]^- \qquad \left[\cdot\dot{\underset{\cdot}{C}}\cdot\right] \qquad \left[\cdot\dot{\underset{\cdot}{N}}\cdot\right]^+$$

The notation is doubtless conventional but that there is a connection between structures is clear. In writing the formula for diborane $[B_2H_4]^{2-}$ H_2^{2+} it is not implied that any particular hydrogen atoms are differentiated from the others, though the compound forms salts.

One explanation of the existence of isomeric borohydrates is that, as in the case of carbon compounds, the double bond implies inability of the doubly bonded boron atoms to rotate. If, then, the α- and β-$H_6B_2O_2$ are represented by the formulæ :

$$\left[\begin{array}{c} H : B : OH \\ :: \\ H : B : OH \end{array}\right]^{2-} \begin{array}{c} H^+ \\ \\ H^+ \end{array} \quad \text{and} \quad \left[\begin{array}{c} H : B : OH \\ :: \\ HO : B : H \end{array}\right]^{2-} \begin{array}{c} H^+ \\ \\ H^+ \end{array}$$

it can be seen that the α-compound might be able to lose two atoms of hydrogen more than the β-compound. It is easy to assign a formula,

$$\begin{array}{l} B : OH \\ :: \\ B : OH \end{array}$$

to the product obtained from the α-$H_6B_2O_2$ by the action of acids. In the case of the β-compound, however, there are alternatives, which may be represented by

$$\begin{array}{c} H : B : OH \\ \\ H : B : OH \end{array} \quad \text{and} \quad \begin{array}{c} H : B : OH \\ .. \\ HO : B : H \end{array} \quad \text{or} \quad \left[\begin{array}{c} B : OH \\ ::: \\ HO : B \end{array}\right] \begin{array}{c} H^+ \\ \\ H^+ \end{array}.$$

The first two formulæ are identical, and represent the same compound, as the B : : B bond is now eliminated. This formula, and that written above to represent the α-compound, include the electronic arrangement $\cdot\dot{B}\cdot$, indicating that the change is similar in either case, though the α-compound loses with acids two more atoms of hydrogen than the β-compound. The alternative formula, which represents the setting up of a $B \equiv B$ linkage, and no change in the electronic structure, has nothing in its favour.

It is also possible to represent the relationship between the α- and β-$H_6B_2O_2$ by assigning to them the formulæ :

$$\left[\begin{array}{c} H : B : OH \\ :: \\ H : B : OH \end{array}\right]^{2-} \begin{array}{c} H^+ \\ \\ H^+ \end{array} \quad \text{and} \quad \left[\begin{array}{c} H : B : H \\ :: \\ HO : B : OH \end{array}\right]^{2-} \begin{array}{c} H^+ \\ \\ H^+ \end{array}$$

The products of the action of acid on them may now be represented by :

$$\begin{array}{l} B : OH \\ :: \\ B : OH \end{array} \quad \text{and} \quad \begin{array}{c} H : B : H \\ .. \\ HO : B : OH \end{array}$$

Here again the process involves a change in electronic structure from .B· to ·B· in each case. As the stability under different circumstances appears to depend mainly upon electronic structure, the process seems to be equally well represented by either of the two systems. However, as the β-$H_6B_2O_2$ does not seem to undergo change into the α-$H_6B_2O_2$, the *cis*- and *cis-trans* formulæ seem to be more probable.

It is evident that the structural formulæ which represent space relationship so well in the case of carbon compounds, though less effectively in the case of the nitrogen compounds, may be used in the case of boron compounds only to indicate the general character of certain chemical processes. Our knowledge about the structures of boron hydride has been recently reviewed by Bauer[39]. Much of the theoretical work, to which complete reference has been made in the review only reveal the limitations of our knowledge of the chemical bond.

Although considerable progress has been made in the field of boron chemistry, a large amount of work still remains to be done. Many facts have to be discovered before adequate solutions could be found for many questions which still remain unanswered. The new knowledge which has been gained in this field has opened a vast tract, rich in interest and possibilities. The study of hydroborons and borohydrates has raised new problems about the nature of the chemical bond. How is it that a hydroboron with a single boron atom in the molecule does not exist? Why does the simplest hydroboron possess a dimeric formula while the corresponding alkyl derivatives are monomeric? Starting with boron halides, it would be interesting to study the replacement of the halogen atoms by hydrogen and to determine at what stage the B—B linkage occurred. It may be mentioned in this connection that preliminary experiment shows that boron bromide and sodium hydride do not react with each other. The study of the reactions of borohydrates with organic reagents may give rise to interesting compounds; the replacement of hydroxyl groups by other atoms or radicals may also be attempted. Additional work is needed to elucidate the mechanism of the formation of the boron hydrides and their relationship with one another. These are only a few suggestions about the directions in which future developments may be made. On account of the instability of many of the compounds, however, the investigations are difficult, but there is no doubt that it is a fertile field which will attract research workers for many years to come. It seems that the solution of the mystery of the nature of the chemical bond lies hidden in the chemistry of the inert gases and that of boron.

Co-ordination Compounds

Due to exigencies of economy of paper and printing cost, it is not possible to speak about many other aspects of modern inorganic chemistry although some of them are also of fundamental importance. Since Werner brought them under an ordered arrangement, the co-ordination compounds have attracted a large number of investigators, and co-ordination theory has become interwoven into the fabric of modern inorganic chemistry. The main trend of work has centred round the determination of the structure of co-ordination compounds with all the powerful physical methods at the disposal of the modern chemist, and old observations have been refurbished in the light of present-day knowledge. Still it has not yet been possible to determine all the factors which determine the co-ordination number of elements, and it is not yet

possible to predict the type of co-ordination compound which a particular element will form with a particular co-ordinating atom, group or molecule. There is increasing evidence in favour of the view that co-ordinate links and principal valencies are closely connected, and, it seems, that it is necessary to determine the structure of co-ordination compounds as a whole and not of the central metal atom only. Investigations of considerable importance on co-ordination compounds are being carried out in this country by Professor P. Rây and his school at the University College of Science, Calcutta.

Mechanism of Reactions and Constitution of Inorganic Compounds

I shall content myself with mentioning one other direction in which investigations may be prosecuted with advantage. Although the use of more exact and more powerful methods is gradually leading to a clearer insight into the course of reactions and into the structure of inorganic compounds, we have not gone very far in our journey in this direction and considerable ground still remains to be covered. While the constitution and structure of most organic compounds have been worked out, analytically as well as synthetically, the same thing cannot be said of many inorganic substances. Despite the fact that an enormous amount of work has centred round glass, we are still in doubt whether it is a definite chemical compound or merely a mixture. In this connection mention may be made of the recent work of Ray, Ganguly and Sarkar[40] who found that whatever might be the original composition of the mixture of sodium carbonate, calcium carbonate and silica from which glass was made, a substance of definite chemical composition was formed. The exact mechanism of many chemical reactions between inorganic substances is still uncertain. A quantitative study of these should be attempted in a systematic manner, using the tools placed at our disposal by the physical chemist.

It must be confessed that our knowledge about the metallic hydrides is still incomplete. It has recently been shown[41] that between the temperatures 25°C and 150°C, nickel forms two hydrides, NiH_2 and NiH of which the heats of formation are approximately 35,200 cals. and 17,100 cals. respectively. Analogous compounds are also formed by cobalt.[42] The heats of formation of these hydrides are comparable to the salt-like hydrides of alkali and alkaline earth metals. It is well-known that some rare-earth metals, zirconium, tantalum and titanium form a class of hydrogen compounds in which there does not exist an exact stoichiometric relationship between the metal and the hydrogen atoms, and these are generally regarded as interstitial compounds. Some of these "hydrides", however, possess high values for their heats of formation, suggesting that there can be little difference in the nature of the chemical bond in a substance such as zirconium hydride, $Zr.H_{1.98}$ (Heat of formation=38,900 cals.) and barium hydride BaH_2 (Heat of formation=40,960). It is one of the puzzling features of this group of substances.

Future of Inorganic Chemistry

The list of topics can, of course, be made much larger and may well include fields of other investigations in which both experimental methods and relevant theories are still lacking. It is clear, however, from what has already been said, that there has probably never been a time when the prospects of inorganic chemistry were so promising as they are to-day.

Those who, like myself, began the study of chemistry some thirty-seven years ago, are filled with envy of the younger men and the great future of scientific research that lies before them. A great and splendid prospect, a land of "rare and refreshing" fruit lies before the inorganic chemists of the present day. Every experimental tool and every theory of the physicist, the physical and organic chemist are at his disposal, ready to be applied to an ever-increasing wealth of material. A combined attack of organic, inorganic and physical chemistry as well as physics must be made on various problems to produce fruitful results. It is, indeed, this drawing together of what were in former days separate "sciences" that offers the greatest hope and the greatest prospect for the future. I do not, however, wish to make "invidious distinctions between the major and minor prophets". It takes many prophets to make good chemistry.

Concluding Remarks

In conclusion, the contemplation of pure chemistry may seem incongruous at the present moment, but there are two reasons for its choice. In the first place, it will perhaps be a welcome diversion amid the plethora of industrial problems that have lately been the portion of many of you. The second and most important reason is that pure chemistry is the bedrock upon which its applications must stand ; applied science must always follow pure science, and if the latter becomes stagnant, the flow of the former also withers up.

It is a saddening thought that whilst knowledge of man is ever widening, it does not always bring wisdom with it. The growing public realization that the powerful tools of science can be used for the enslavement and destruction of man has given rise to bitter questions and charges. The question arises, of course, because science as a method for gaining knowledge of nature also brings with it the power of controlling nature, and power can be used by evil men to do evil more obviously and dramatically than it can be used by men of goodwill to do good. This is true of many things of life. Language is a powerful instrument which can be used not only to propagate knowledge and to mirror spiritual insight but also to spread false and destructive propaganda. The possibility of misuse, however, is not an argument for no use at all. It would be fantastic to suppose that chemists are a callous and blood-thirsty class of people because of the part chemistry plays in modern warfare. Theirs is a dispassionate quest altogether. Science is at once a method, a confidence and a faith. It is a method of controlled and repeatedly checked observations and experiments, objectively recorded with absolute honesty. It is a confidence that truth can be discovered. It is a faith that truth is worth discovering. The study of science should lead to lessen the antagonism and to create better understanding between the peoples of the world. However, it did not look that at times ; it does not look like it at the moment. Some of the best brains are working now in contemplation of destruction. Gatherings of scientific men must, however, be held in order to endeavour to contribute to the understanding between the peoples of the world. Really speaking, the things that divide us are trivial as compared with the things that unite us. Science has laid the foundations of a co-operative world, because science relates to the welfare of all men everywhere. The best that the applications of science have produced anywhere in the world has always been available to serve the race of men, regardless of nation or colour.

In science there is neither dictatorship nor oligarchy ; it is a free democracy comprising all talents.

The age of distinct human societies, indifferent to the fate of one another, has passed for ever. The great task that will confront us after the war is to develop for the community of nations new areas and techniques of co-operative action which will fit the facts of the present-day world. Science is the centre of unity round which men of differing cultures and faiths can combine ; in the wide and varied fields of science alone, the human race, by pooling its brains and resources, can add to its own well-being. Only as we begin to build, brick by brick, in these areas of common interest where co-operation is possible and the results are of benefit to all, can we erect the ultimate structure of a united society.

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SECTION OF GEOLOGY AND GEOGRAPHY

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THE BOMBAY ISLAND

(A Review of Geographical and Geological Features)

(Delivered on Jan. 4, 1944)

Before proceeding with my address I wish to express my sincere thanks for the great honour done to me by my colleagues in electing me President of this year's session of the Geology and Geography Section. For a teacher, like myself, it is not only a great honour but a great privilege which I accepted with considerable trepidation. As a rule most of the professors are working under a great handicap, because the greater part of their time is spent in undergraduate teaching. I believe that in selecting me for this honour you had in mind the idea of encouraging a small band of university teachers working in only a few colleges in India. I am also deeply conscious of the great responsibility that I have accepted and I trust that with your kind co-operation and indulgence, the proceedings of this session will be successful. It is this consideration that has emboldened me to accept the responsibility of presiding over the deliberations of this section.

An old worker in science looks greatly back on his attendances at the Science Congress Association meetings not only as delightful human events but as red-letter days in his own development, as milestones in the unceasing march of his subject, and as helps in the hard task of keeping himself more or less in step. I have spent most of my time in teaching and that too in Bombay. Bombay is also *Urbs Prima in Indis*. Consequently, I have chosen the 'Bombay Island' as the subject of the remarks I propose to make this morning. I, therefore, have ventured to take this opportunity to examine the outstanding aspects of this Island and make some observations on them in the hope that I may elicit further information from future workers.

But, before I turn to the substance of my address, I feel that I must avail myself of the privilege as a President to wander from my object and speak briefly of a matter that is very much in my mind. I refer to the teaching of Geology and Geography in our colleges and universities. The necessity for the education of these branches of science is now universally admitted. Geology and Geography as fundamental sciences have not always been—and still in some quarters are not—recognised by other scientists in our country. The present system of education omits to give as much importance or rather that which is due to these branches. But I hope that this appeal of mine may reach beyond the walls of this room and convince the college and university authorities that these fundamental sciences have a message of vital importance to mankind. The aim of these sciences, as you all know, is to decipher the records of past life, and to translate the story into human language. One of the crying needs of the day is a sound education in these sciences. The fundamental distinction

between education and training is one which is very apt to become blurred. Training for some specific taste should follow, not accompany, the process of education.

Systematic and scientific teaching of these subjects in India has begun very recently and up till now only a few colleges and universities are teaching them. There have always been a few, however, who recognised then, and even now, that our universities had a wider part to play in their education. It is high time that these sciences were considered as fundamental sciences, and their importance to mankind in general were properly realised in this country. In India there is a tendency in some quarters to look upon basic research as a luxury,—pleasant, satisfying but unnecessary. This is unfortunate because the research ability and effort of its people constitute the greatest resource of the nation. The whole progress of science depends on filling in the gaps in our knowledge of the nature of things. In the case of basic research, we simply know that we are on the trail of a fact which explains something not previously understood.

This period might well be called the "Age of Getting Together". I hope and believe that we are at the beginning of a new era of closer co-operation and better understanding. Having unburdened myself of these remarks to which I have been impelled by a haunting fear that proper attention, importance and place are not given to these sciences, I propose to pass over to the subject of today's Address.

Evolution of the Island and Topography

Long before the dawn of history, possibly prior even to the advent of man upon the earth, Bombay formed a part of the mainland of India. Successive earth movements subsequent to the volcanic activity must have caused faulting along the present west coast of India and the portion which originally was to the west of this fault line went down into the sea ; and this abrupt stoppage or scarp-side near the Bombay coast is the result of this faulting. The age of this faulting is post-Deccan Trap and probably as late as Pliocene. This is quite evident from the fact that the Deccan Traps are several thousand feet thick along the Bombay coast and gradually thin down eastwards. About this period the existing ridge of the Western Ghats must have broken up into several islands lying off and fringing the western coast of the Peninsula. The present Island of Bombay is one of the multitude on the western shore of India.

Ptolemy, the Alexandrian scientist, was the first to vaguely designate (A. D. 150) Heptanesia, as a locality situated on the Pirate Coast, between Bombay and Goa, which Lassen identified with Bombay, the harbour of which was believed to be formed of seven islands. In fact the present Bombay Island is constituted of *seven* islands. These islands, starting from the south, were (Map I) : I. Colaba ; II. Old Woman's Island ; III. Bombay (central island) ; IV. Mazagaon ; V. Parel-Sewri-Sion ; VI. Mahim ; VII. Worli. These seven islands were separated by narrow creeks from one another often contracting to a few scores of yards in width, some dry at half-tide, and widening and deepening as they approached the sea. The islands except Mahim for the most part rose into round or nearly flat-topped hills, varying from 100 to 200 feet in height.

When man made his first home in the clusters of these islands, he was yet in the Stone Age. Some palæolithic implements have been collected by De Terra, Col. Todd and Kalapesi from Kandivli (Bombay). It appears that the Kolis (the aborigines who occupied these islands) brought with them, most probably from Gujarat, their patron goddess,

which under the title of "Mumāi" is still worshipped as a village goddess in Kathiawar. Regarding the origin of Bombay, the derivation is believed to be from the tutelary deity of the then islanders—"Mumbā Devi" or "Mumbā Āi", the patron deity of the Kolis. The Hindoos even today speak of the city as 'Mūmbāi'. Her temple first stood on the central island, that is, the third of the group, which in course of time during the Portuguese possession, grew to be called 'Mombaim'. Later on, during the British occupation, this gradually changed into Bombay, and spreading to the other six islands ultimately affixed itself to the whole Province. Her shrine was situated in the immediate neighbourhood of the site now occupied by the Victoria Terminus of the G. I. P. Railway. Later on (about 1750) the temple of *Mumbā Devi* was removed to its present site, at the south-west corner of the great Mumbādevi Tank in the very heart of the city.

The history of Bombay commences in 1534 with the cession of these islands to the Portuguese by Sultan Bahadur of Gujarat. Thus the 'Heptanesia' passed from Mahommedan into Christian hands. In 1661 the marriage treaty of Charles II of England was signed, and the mixed dowry brought by Portuguese Princess Catherine included these seven islands. Afterwards these islands were given to the Honourable East India Company in 1668 at a nominal rent of £10/- per annum. The Hon'ble East India Company came to an end with the Mutiny, so that in 1857 they reverted to the Crown. About 1673, the original seven islands had become four. This was effected by the silting up of the breaches and overflowings of the sea in some places. The four islands were: (1) Colaba and Old Woman's Island; (2) Bombay, Mazagaon, Parel, Sion and Dharavi; (3) Mahim; and (4) Worli. The remaining islands have been gradually, by the end of the eighteenth century all welded together by raised causeways, embankments and by the filling up of estuaries. The shallow channel between Sion and Trombay was also silted up by the middle of the nineteenth century.

The southernmost of these islands (No. I) lay as a narrow tongue of rocky land, now called Colaba. The Kolis lived here in this island, which thereby acquired the title of *Kolā-bhat*—the Koli hamlet, now Colaba. Formerly Colaba was divided in two by the sea. The smaller half (No. II) bore the title of '*Al-Omanis* Isle' or the Island of Deep-Sea Fishermen. With the advent of the English this changed into Old Woman's Island; the two were welded together by a causeway.

Going northward there was a wider channel, and to the opposite side of it there appeared a curiously-formed land resembling in some degree the letter 'H'; this was (No. III) the central island (Bombay), Map I. The channel between Old Woman's Island and this island was crossed by a ferry-boat worked on a rope; the distance between the jumping off spot from Old Woman's Island (Lower Colaba) to Apollo Bandar on Bombay Island was 300 yards. The creek was filled up and a causeway was built in 1858. The western portion of this was composed of a ridge of hills (Malabar and Cumballa) covered with rough jungle; the Malabar Hill runs down southward from Walkeshwar in a point into the sea. The name is supposed to have been derived from 'Vālukā Ishwar', meaning 'Sand-Lord'; the *Linga* is supposed to have been erected there when '*Rāma*' was on his journey to '*Lankā*' (Ceylon). The Walkeshwar temple was erected in honour of this 'Sand-Lord'. From the eastern edge of its nearest promontory going northward there was a rude landing-place or beach used, doubtless, by the aboriginal fishermen; around this spot had grown up a species of shrub or tree, and the place was known as *"Pāllav Bandar"*—the harbour of clustering shoots. From *"Pāllav'* to

"Pālo" and final alteration during the English occupation to Apollo ; the Apollo Bander is one of the best known places of present Bombay.

The place now occupied by the Fort and the Esplanade as well as a part of the Native Town up to Pydhoni belonged to this island. It is probable from the aspect of the shore (Back Bay) that this had a direct connection with the hilly ridge (Malabar--Cumballa) on the west by a sandy ridge between the present Girgaon Road and the sea. A very slight diminution of the existing height would have allowed the sea to sweep clean through from Mahim and Worli to Back Bay—present Chaupati. The word Chaupati really means *"Chow-pati"*, i.e. four channels ; it might have formed four channels in the neighbourhood of Girgaon. The sea then flowed through the Worli and Mahim breaches at high tides and swept over those regions which now form the central sections of the city—the 'Flats'. Girgaon is derived from *"Giri-grāma"*—the hill-village, which was situated at the foot of Malabar Hill in the neighbourhood of Back Bay. The eastern side of this landmass was bounded from the north by a rocky ridge, which was called *'Dongri'* or the hill tract.

This island was severed from the next (No. IV), Mazagaon, by *Umbar-khādi*—a creek of the "Fig-Trees" (*Fecus glomerata*) and *"Pāi-dhoni"*, meaning Foot-wash. Pydhoni, which is situated in the neighbourhood of Mumbādevi, was a ferry where persons arriving from Mahalakshmi, Mahim and Salsette by boats used to land after crossing Umbar-khādi creek, and get their feet washed in a shallow creek (Pydhoni) in approaching Bombay (the central island) on foot. The neighbourhood of the Mazagaon Gaol is termed *Umbar-khādi ; 'Khādi'* is the word which is generally applied to salt-water creeks, dry at ebb-tides. This breach on the eastern side—Umbarkhadi—had apparently been silted up by the time the British occupied Bombay. Passing across the Fig-Tree creek (Umbarkhadi) to the shores of the fourth island we enter the 'Fish-village' or *"Machha-grāma" ;* and going westward on that island was a level stretch of land extending as far as the marshy domain of the sea, the present Byculla.

After Mazagaon, going northward, across the ocean's intercepting arm there came the fretted coast of a large island, Parel-Sewri-Sion (No. V) ; when the British got these islands, the creek between the fourth and the fifth islands seems to have been almost silted up. In the extreme south lay a tamarind-covered valley, called *"Chinch-pokli"*, the dale of Tamarinds (*Tamarindus Indica*), now known as Chinchpooghly. The valley was succeeded by level ground, containing the village of Parel, enclosed on the east by rising ground and on the west by the sea. On the eastern side of the rising ground lay a small promontory called *"Shiv-vādi"* or *"Shivādi"* containing a shrine of *'Shiva' ;* from *'Shiv-vādi'* to *'Shivāri'* and then to 'Sewri'. Lastly on the verge of this long island lay the Boundary-hamlet, *"Simva"*, i.e. limit or boundary ; it is now called Sion. It was the last inhabited spot before one voyaged across the strait (Mahim river) to the island of *"Shāshashti"* or sixty-six villages, now Salsette. On the north-east corner of this island is a hill on which was built a fort—the Sion-Fort. The breach between Sion and Mahim was filled up about 1710-1712 ; thus the fifth island was joined to the sixth—Mahim. Formerly, Trombay was separated from this (the fifth island) by a bay and mud flats of the harbour ; this swampy area was gradually silted up ; later on the low land between Sion and Trombay was reclaimed and roads were built ; thus Trombay became a part of the Bombay Island. Towards the south at the foot of the Trombay hill, about 1,000 feet high, is a tomb, called Pir Pāv.

To the west of the fifth island (Sion) was Mahim (No. VI), one of the oldest known, which begins just after the embankment from Sion-Dharavi. On the north-west point of the island is Mahim town. In the historic times, about 1300 A.D., this town was a city called "Mahikāvati" and hence the name 'Mahi' or Mahim has been derived. It was the capital of Bhim Raja. During the Mahommedan suzerainty, the shrine of *"Kālkā Devi"* or *"Kāli"*, goddess of the aboriginal Kolis was removed to the central island (Bombay) of our Heptanesia. This has eventually left the legacy of its name to that modern road of the city, 'Kālkādevi' or 'Kālbādevi' Road. The Mahim Fort was situated upon the western point of the island in a low, sandy foundation. There was the old *Bandar*, on the opposite side of the Mahim river, present Bandra ; there was a ferry-boat employed constantly in carrying over passengers. From the Mahim Fort to the southern end of this island which has been joined to the seventh island—Worli, there is a fine large bight, between the Worli Fort and the Mahim Fort, called the Mahim Bay, in which there is a beach called the Mahim Sands. The beach is a few feet above high-water mark and it chiefly prevents the sea from overflowing the centre of the island ; here there are no strong waves or serfs. This island, unlike other islands, is sandy.

At the extreme south end, Mahim (No. VI) was separated from the seventh island—Worli, by a breach or channel ; though at low-water it was mostly dry, at high or spring tides it was not passable on foot. This breach, between Mahim (No. VI) and Worli (No. VII), was dammed up about 1712. Rocky and narrow, this island (Worli) lay like a carelessly-placed barrier in the path of the tide stemming the direct onslaught of the ocean, yet allowing it at the same time to creep through breaches at both the extremities. The most noteworthy feature of this island was a fine grove of Banyan Trees (*Fecus Bengalensis*); and this led to the name *"Wad-ali"*—'Banyan Row', being applied to the whole island. Later on, it became "War-ali" which has now become 'Warli' or 'Worli'.

Worli, the last of the seven islands, is situated on the western bounds of the Bombay Island, and there were two breaches at the extreme ends of it. It is mostly a high, rocky land, running in a continued ridge. At the extreme northern point, on a steep promontory, jutting out into the sea is the Worli Fort. The town, situated at the foot of the hill on which the Fort stands, is lying along a fine sandy beach. Near the town is a spring of palatable water. Here there is a landing-place much used in the past. At the southern extremity of Worli (No. VII) the hill falls down with a steep, broken descent, and the rock tails out southward into the great breach, the largest of all, between the southernmost point of Worli (No. VII) and Mahalakshmi, the north point of Cumballa Hill (No. III). The Vellard (from Portuguese, *Vellado*=fence) between Mahalaxmi and Worli was constructed during the Governorship of Mr. Hornby in 1783. This breach is known as 'Breach Candy', meaning the breach at the mouth of the hollow or pass. The word seems to have been locally applied to the break or gap through which the sea flooded the 'Flats'; while 'Candy' is the old spelling of the word *'Khind'*, meaning a pass. Through this breach the tide would come racing over the Byculla 'Flats' sweeping across the whole Bellasis Road, thence to Grant Road, invading Khetwadi, and also swept past through Duncan Road, onward through the Bhendi Bazaar, and quite up to and northward of the identical spot known as Pydhoni.

The building of the Hornby Vellard rendered available for settlement and cultivation the wide stretch of the 'Flats', and resulted in the welding of the eastern and western shores of the Island into one united landmass;

the present Bombay Island. The Island of Bombay, thus artificially connected, throws out a long projection southwards from one (western) extremity forming the Malabar Point (Walkeshwar Point) ; while the other (eastern) stretches out southwards nearly parallel to Malabar-Cumballa ridge, but extends much more seaward (Colaba Point). The two promontories terminating at the Malabar Point on the south-west, and at the Colaba Point on the south include a great bight (Back Bay) between them, Map II.

From the Malabar Point (Walkeshwar) to the Cumballa Point (Mahalaxmi) is a fine bold ridge of black lava (andesite) nearly three miles in length and about half a mile across, maintaining an elevation close to 200 feet above the sea. The principal feature of this ridge is that it is more or less precipitous towards the east, while it slopes more or less suddenly towards the west. The ridge continues on to Mahalaxmi where it sinks under the level of the sea ; from this point for about half a mile the ridge disappears under the sea. It re-appears in the eminence—the Ram Hill (Love Grove) and it once more disappears under the sea and once again re-appears just beyond forming the edge of the Worli Hill. At Worli village it disappears under the sands and alluvium ; then it rises suddenly across the Mahim creek at the promontory of Bandra, and continues as a great sea-wall all along the western shore for ten to fifteen miles at least towards the north as far as Danda (Salsette).

The other rocky ridge (east shore) extends from the Colaba Point (Lighthouse) on all the way to the Sion Fort, on the eastern side of the Island, facing the harbour. Instead of forming one continuous ridge, like the one from Walkeshwar to Mahalaxmi it often sinks down to the level of the sea, where it is covered over with alluvium, and is only traceable in wells, quarries and other excavations. It sometimes rises into knolls, sometimes into little hills of about 100 feet in elevation, e.g., Mazagaon Hill, Sewri Hill, Parel Hill, etc.

The present Island of Bombay consists of a low-lying plain (almost perfectly flat, about a fourth of it being in reality under the level of the sea) about eleven miles long by about four miles broad, flanked by two parallel ridges of low hills, which intersecting below high-water level beyond Colaba, form the dangerous reef marked by the Prongs Lighthouse. It covers an area of about thirty square miles, and is united at its northern extremity with the larger Island of Salsette and so it is continuous with the mainland of India, by means of two causeways, one at Mahim and the other at Sion, and two railway embankments and bridges, Map II. The shape of the Bombay Island as a single landmass is more or less trapezoidal ; and its location may be given as Lat. 19°N. and Long. 72° 30′E.

With respect to its relations with the mainland—India, the Bombay Island is separated in the north from the mountainous Island of Salsette, by a channel (estuary of the Mahim river) narrowing to a part not more than about 120 yards wide. To the south and east of Bombay is its harbour, in which there are several mountainous islands (e.g., Elephanta) that lie scattered between the Bombay Island and the mainland of India. The harbour or the estuary is about eleven miles long and about six miles across in its widest part.

We have just seen the gradual evolution of the Bombay Island, as a single unit, from seven different islands, and now we shall have a glance at the varieties of rocks in a small Island like this.

Rocks : Their Occurrence and Principal Features

Here I intend to give an account of the various rocks found in the Island confining myself chiefly to descriptions of observed facts.

Geologically the Island appears to consist of a conformable series of the Deccan Trap lava flows, intercalated with the fresh-water sedimentary beds. The general dip of the rocks is 10° to 15° towards the west ; and the general strike is N. 10° E. to S. 10° W.; this dip, which has given the rocks of Bombay a ridge-like appearance, is, most probably, due to the disturbance after the consolidation of the highest Deccan Trap flows. The rocks are well seen in the hills of the western and eastern ridges, while the central plain—the Flats—is covered with recent alluvial deposits.

Though the Deccan volcanic activity is supposed to have come to an end after the highest lava flows, yet, in this Island, it seems to have lasted a little longer ; during this period there were *local* effusions of lava that penetrated between the sedimentary beds underlying the highest lava flow and the basement flow of the Island. These effusions are called "*secondary*-effusions" to distinguish them from the primary flows. It appears that these *secondary*-effusions must have taken place during the foundering of the land which extended towards the west of the present coastline of the Peninsula after the highest Deccan lava flows had consolidated.

I have followed Carter's plan and also used his Geological Map to describe the occurrence of various rocks in the Island, with some modification as regards rock-names. The various rocks are divided into *four* periods, which are still open to question. The third period is again sub-divided into four effusions : the first being the last of the Deccan Trap lava flows (the highest in the series); while (*a*) second, (*b*) third and (*c*) fourth being *secondary*-effusions, Map III.

The First period or the earliest as far as Bombay is concerned was one of the later volcanic effusions of the Deccan lava flows (probably the last but one) which forms the basis (substratum) of the Island.

The Second period was a period of quiescence during which the fresh-water, lacustrine strata were deposited. To this period belongs the well-known fresh-water formations of Bombay, which are the youngest among the inter-trappean sedimentary beds. They are the oldest sedimentary rocks exposed on the Island. It is possible that this lacustrine fresh-water deposit originally extended all over the Island of Bombay and further. Its present position in some localities appears to be under the overlying highest lava flow of the series and resting on the amygdaloidal basalt, which is a subsequent *secondary*-effusion of the nature of an intrusive sheet (a sill).

The Third period was the period of the last volcanic effusion of the Deccan Trap lava flows forming the highest and, therefore, youngest lava beds in the series. After this there were *three minor and local effusions* in the Island, which, very probably, are responsible for the present topography of the Island. This highest flow caps the main ridges in Bombay and was, probably, continuous all over the Island ; and it also overflowed the then plain of Bombay having fresh-water lakes and swamps. The flow then must have been horizontal all along ; and its westward dip must have been imposed upon it later on by those subsequent *secondary*-effusions.

(a) The "*secondary*-effusion", subsequently coming up under this main flow (the highest lava flow of the Deccan Trap) and not finding a ready outlet forced itself, forming a sill (amygdaloidal basalt and greenstone), between the basement lava bed and the fresh-water strata, underlying the highest lava flow, intercalating and breaking them up. This effusion apparently could not burst through the overlying highest lava flow; and was, most probably, responsible for raising up the longitudinal ridges, bordering the eastern and western sides of the Island.

(*b*) The next "*secondary*-effusion", which is termed as Volcanic Breccia took place after the preceding effusion which consolidated into the amygdaloidal basalt and greenstone, is proved by the presence of the fragments of the previous effusions as well as those of the fresh-water strata in this rock. It is of wide extent, composing the plain and chain of small hills which bound the north-eastern part of the Island. The volcanic breccia of Sion points to the existence of a volcanic vent at no very great distance from where it is found. In Bombay, probably, there are places, which doubtless were the foci of volcanic eruptions later than those which formed the highest Deccan Trap lava flows. These, as marking weak points in the earth's crust, may also have vents for the earlier eruptions, and may now be lying beneath the waters of the harbour and the sea outside.

(*c*) Lastly, there is a record of one more *secondary*-effusion after that of the Volcanic Ash and Breccia. The occurrence of this was proved by the existence of 'Dyke-like Volcanic Breccia' through the volcanic ash and breccia beds. These dyke-like masses were rather rare, being noticed in restricted places in the north-eastern part of the Island.

The Fourth period (or the last) was the one when all volcanic activity had stopped for ever, and the deposition of estuarine-clay and marine-sand began in the area ; this seems to belong to, probably, the newer-Pliocence period. After the partial depression, this process of deposition started in some areas which were lowered down below the sea-level. The strata, from the lowest, are composed chiefly of (1) The Blue Clay (Submerged and Reclaimed Silt) imposed upon the Traps or on its weathered surface. Above it comes a stratum of (2) Shell Concrete (Raised Sea Beaches ; it is the marine-sand composed wholly of sea shells, that lived below the low-water mark, and corals, and cemented together by calcium carbonate. In places, it is caked together into compact masses to which the name has been given of 'Littoral Concrete'. Lastly, over this comes (3) the Alluvium (Lagoon Formation) ; a recent formation about ten feet above sea-level.

Fresh-water Formations.—They are the oldest beds exposed on the Island. They consist of more or less indurated argillaceous or argillo-calcareous shale with small quantities of coal in some parts of the Island. They lie immediately below the highest lava flow of the Deccan Trap series. These aqueous strata by their fossil contents (frogs, cyprides etc.) are proved to have been deposited in fresh-water lakes. The argillaceous shale appears to have been deposited generally in thin layers of impalpable powder (ash). Towards the lower part of these beds are found in abundance skeletons of small frogs. Their bodies have evidently been deposited near the spot where they died, as the whole skeleton is often found perfect. In some cases the skeleton appears to have been dragged along the surface of the shale in which it is entombed, and probably this might have been by the wind. Tortoises were collected some years back in the thin stratum of this lacustrine formation, which was then exposed in the scarp of blue-black trap at the foot of the Nawrojee Hill (Mazagaon) which no longer exists.

These small-sized frogs were first described by Owen in 1847, as *Rana pusilla*. Stolicza re-examined them and transferred them to the genus *Oxyglossus* (or *Oxydozyga* as it is now known) in 1869. Noble in 1930 recognised the bufonid nature of these frogs and transferred them to the genus *Indobatrachus*, which was created for their reception. Chiplonker in 1940 discovered a new species associated with *Indobatrachus pusillus* (Noble), and he named it as *Indobatrachus trivialis*. This new species has

a little longish appearance as compared to the former (*pusillus*). The genus *Indobatrachus* has its nearest allies in some of the living Australian bufonid genera..

The outcrop of the fresh-water beds at the Love Grove cut is almost under high-water mark. The beds that protrude from under the Malabar Hill seem to be an extension of those seen at Mahalaxmi, at *Māmā Hajiāni* (a small island opposite Mahalaxmi), at Love Grove and again at Worli Hill. A carbonaceous shale, with impressions of frogs, can still be seen on the eastern side and at the foot of Worli Hill, below the thick mass of *moorum* and trap ; here the frog-bearing beds are about 25 feet above the mean level of the sea. The layers below the lowest frog-bearing bed at Worli appear to have been broken into and partially fused by the subsequent *secondary*-effusion coming in contact with them. But at Sewri the aqueous beds seem to have been contorted, fused and even jasperised to a certain extent. This phenomenon may give an additional support to Carter's hypothesis, namely, that it was the *secondary*-effusion (amygdaloidal basalt and greenstone) that forced up the overlying beds ridge-like. The Bombay fresh-water beds are exposed on both the sides of the Island and they run out into the sea ; they are, moreover, continued in Salsette. They also partake in the westward dip noticed in the highest volcanic lava flow, which they underlie. It is probable that no description of these aqueous formations, which is true of one place would wholly apply to another place. The fresh-water beds at Worli are being rapidly quarried away ; and at the present rate of quarrying these valuable and interesting frog-bearing beds will soon be completely wiped out, like those tortoise-bearing beds at Nawrojee Hill (Mazagaon).

Andesite.—These are the highest lava flows that cap the ridges (Malabar, Cumballa and Worli) on the western side of the Island from Walkeshwar to the Worli Fort. They rest immediately on the fresh-water strata, but are nowhere seen being pierced by any of the *secondary*-effusions. It is massive, compact and from bluish-black to black in colour ; it is very strong and tough and marks glass. Its sp. gr. is 2·85. The rock breaks conchoidally and it is being quarried to a small extent for use as rubble and metal in the foundations of buildings. For road making the metal is not quite suitable, the angular fragments being too sharp. Also it has no building properties.

It is often intersected by hexagonally reticulated quartz veins ; in some places it is traversed by strong joints, between which large spaces have been formed, or the rock is intersected by joints leaving great pillar-like columns detached from the rest of the cliff. On the face of the Malabar Hill overhanging Back Bay it is rudely columnar and is stratified in the Worli Hill area, showing hexagonal prismatic arrangement. It is a very noticeable fact that the whole depth of rock on the eastern side of Worli Hill has decomposed into *moorum* by concentric disintegration of the trap, leaving round cores of various sizes. The larger and less weathered ones still show the typical trap characteristics. It is rather strange and peculiar why this trap, which apparently is harder than the other varieties, has weathered here at Worli Hill to such an extent as to produce a bed of *moorum* over 100 feet in thickness. The other hills in Bombay are covered with a comparatively thin layer of soil.

The unweathered rock presents an appearance unlike that of any other trap rock in Bombay. Its main difference from the gray basalt of Colaba or the greenish-gray trap (greenstone) of Parel and Sewri of the eastern ridges lies in its black colour, its compact structure and minute texture, and its more rectangular disintegration. This rock is also found at low-water mark about the little island—*Māmā Hajiāni*, opposite Hornby

Vellard ; this marks practically the centre of the vanished portion of the range. The island upon which the *dargah* (tomb) stands is also composed of this rock, which extends northward and constitutes Love Grove and Worli Hills. Thus this rock forms a vast sea-wall from the Malabar Point to Bandra and even as far north as Bassein.

Carter thought the rock of the western ridge (Malabar) and the rock of the eastern ridge (Colaba) to be part of one and the same formation and so he included both these rocks under one term "Basalto-Dioritic Tract" as shown in Map III. It has been found that the Malabar-rock is somewhat different from the Colaba-rock and so the former is termed 'Andesite', while the latter is called 'Basalt'.

Basalt.—It is a compact, hard and gray trap, which resembles the normal basalt of the Deccan Plateau. The sp. gr. is 2·91. Apparently this rock forms the hills of the eastern ridges, except those bordering the north-eastern part of this side of the Island ; and it appears to extend continuously from the southern extremity (Colaba Point) to the northern extremity (Riwa Fort). It also forms the Trombay Hill. The apparent continuation of this rock is interrupted by breaches or breaks here and there ; and it diminishes in height towards both the extremities. This rock forms the whole of Colaba and the eastern part of the Fort and the Esplanade ; it, probably, extends into the harbour on one side and appears in Back Bay again on the other. According to Wynne, these trap flows though apparently nearly horizontal, yet, taken collectively, seem to have a slight dip to the north-west.

Amygdaloidal Trap.—It is a variety of the *secondary*-effusion, that penetrated between the basement lava flow and the fresh-water formation and consolidated there forming a sill. This rock is greenish in colour, not very hard and breaks with a splintery fracture. It is generally vesicular ; the vesicles contain secondary minerals like calcite, quartz or zeolites, forming amygdales. This rock is often seen to pass into solid greenish trap, resembling dolerite, which is here termed 'greenstone'. This rock constitutes most of the hills in the eastern ridges, especially in the neighbourhood of Parel, Chinchpoogly and Sewri.

Carter did not differentiate this formation into two distinct rock types —'amygdaloidal trap' and 'greenstone'—and so he included both, amygdaloidal trap and greenstone, under one term "Amygdaloid", as shown in Map III.

Greenstone.—It is chiefly a variety of amygdaloidal trap (*secondary*-effusion). It is generally found associated with and often passing into amygdaloidal variety. The rock is principally a greyish-green trap with an appearance, when coarse-grained, of a dolerite. It is here called greenstone just to distinguish it from the normal grey basalt of Colaba. Although this rock, locally varying, still so closely resembles the trap that there is no reason to doubt its belonging to the same group. It is compact and hard ; its sp. gr. is 2·9. It is greenish to greyish green in colour ; but when exposed for a time to the weather, it becomes darker and marked with small spots. It breaks up in masses of any size ; it is easily dressed with the hammer and chisel ; it is largely used as a building stone. It makes an excellent road metal. The rock is jointed and has a rough-bedded appearance owing to the predominant development of discontinuous horizontal joints. The rock is found in abundance in the neighbourhood of Parel, Chinchpoogly and Sewri. It is sometimes cavernous ; the cavities, well exposed in some of the quarries at Sewri, were sometimes very big, e.g., 30 feet long, about 20 feet wide and 7 feet high. The sides, roof and ~~the~~ space of the bitumen on the floor of these cavities were studded with beautifully formed crystals of secondary minerals.

The secondary minerals are: (*1*) Calcite or calc-spar is abundant and often occurs as a rhombohedron either flat or steep, nail-head spar and dog-tooth spar ; it also occurs as barrel-shaped crystals. (*2*) Quartz crystals are widely distributed ; occasionally, beautiful, little doubly terminated colourless crystals are found ; it is generally colourless and transparent but sometimes violet or black ; and sometimes it forms stalactites. (3) Zeolites of which the following varieties have been noticed are, as a rule, beautifully crystallised with brilliant and glassy crystal-faces and often with delicate colouring: (*a*) Stilbite is usually white and the crystals are grouped in sheaf-like aggregates, this form being a very characteristic feature of the mineral. (*b*) Prehnite is of a sea-green colour ; the individual crystals are closely aggregated in radiating forms, with rounded external surfaces ; the botryoidal forms (like a bunch of grapes) being specially characteristic of the mineral when taken in conjunction with the pale green colour. (*c*) Apophyllite is milky white to colourless ; it occurs in thick rectangular prisms with often truncated summits ; it is remarkable for the size and perfection of its tetragonal crystals ; at times forms occur with a cube-like aspect. (*d*) Natrolite is cloudy or opaque, and of a white or pinkish colour ; it usually occurs in slender, acicular crystals ; the crystals often have the form of very delicate needles growing out in thick clusters from the surface of the rock ; frequently the needle-like crystals or fibres are closely aggregated in compact, radiating groups. (*e*) Analcite (analcime) is often colourless but sometimes reddish-white or pink ; the very common form in which it occurs is trapezohedron. (*f*) Thomsonite is generally white in colour ; usually it occurs in radiating crystalline masses and sometimes columnar ; sometimes it occurs in spherical massive forms also radiated with several centres and of varying colours, hence of much beauty. (*g*) Laumontite is generally white or yellowish in colour ; it is translucent when first exposed, but becomes opaque and brittle on exposure; the water is held so loosely that it escapes in a dry atmosphere and the transparent glassy crystals crumble to powder. (*h*) Scolecite (Scolezite) is white in colour ; usually occurs in tufts composed of very delicate acicular silky crystals ; also sometimes it is in fibrous forms, nodular or radiating prismatic crystal groups. (*i*) Heulandite is generally white or brown in colour ; it often occurs in globular forms with pearly lustre.

Volcanic Breccia.—It is composed chiefly of angular fragments of various sizes of the fresh-water formation and of the foregoing effusions cemented together in an ashy matrix. Its structure changes greatly. Its colour changes from reddish to greenish but its mixed, mottled and heterogenous appearance distinguishes it from other rocks with which it is generally associated. This typical formation is exposed in a large tract, which extends from Carnac Bandar to Sion Causeway. At Sion the hills are more or less conical, rising somewhat abruptly from the muddy flats. These conical hills are formed of reddish-brown breccia.

Dyke-like Breccia.—These were not greatly different from the breccia just described, but somewhat more compact and of slightly different texture. It is not possible to locate them now, but Carter has described—"There is a dike of it (breccia) seen passing up through the westernmost of the hills at Sion. These dikes, then, constitute a fourth Effusion, from their passing through the third effusion". Wynne has remarked—"Dyke-like masses occur in the volcanic breccia of Sion, but from their similarity to the neighbouring rock, it is all but impossible to say that they do not owe their appearance to the occurrence of parallel master-joints."

Lydite-like Rock.—It is a peculiar black rock that constitutes Antop Hill. The hill is more or less conical, rising somewhat abruptly ; and so

it is an exception to other trappean hills. The whole rock of this hill is of a curious, compact and almost flinty kind. It is jet-black in colour and unless very closely examined the rock may be mistaken for the lava flow (andesite) of Malabar Hill. A very careful examination, especially in hand-specimens, discloses characters of a sedimentary rock, baked and hardened. It has a hardness slightly below 6. It is compact and has a semi-lustrous glistening semi-conchoidal fracture. It is traversed by lines resembling lamination. It often contains crystals of iron pyrites, calcite and amethyst, smoky or colourless quartz. Slabs detached from the cliff by the weather and lying at the foot of the hill are of a tabular character such as might be assumed by a flaggy rock on breaking up. In quarries it breaks into small, uneven, splintery blocks. It differs greatly in appearance from any of the trappean rocks ; also it has none of the appearance of a dyke—no wall or joint-fissures such as dykes often show, running in the same direction as their strike.

Carter considered this rock to be the result of the action of the magma around on stratified clay-beds lower down ; these beds were subjected to fusion and subsequently brought up from beneath by a volcanic effusion. Consequently, he called this rock a "Lydian Stone", as shown in Map III. Wynne does not agree with Carter's view and he considers this rock to be a 'melaphyre'. He has also remarked that the ridge formed by Antop and Muddly Antop Hills was crossed by a fault.

Blue Clay.—It is a stiff, plastic deposit of clay of a fine uniform structure ; it is generally calcareous and charged with common salt. It fills up the central or lagoonal depression—the 'Flats'—of the Island ; it, with mangrove roots, is found in wells in Mahim area, and in some wells around the western portion of the Esplanade. It contains very few organic remains, but is full of mangrove roots. In the Mahim area gypsum was found in good quantity in this clay deposit. The clay is also full of nodular masses of greyish-coloured limestone—the *kankar* formation.

Littoral-Concrete (*Beach Conglomerate*).—It is generally found lying over the Blue Clay. This upper marine formation seems to belong to the recent deposits, the materials of which they consist being identical with those now on the sea-shore. In this formation the material is sometimes loose, most frequently it is united by a calcareous cement into a tolerably firm shelly rock. It is chiefly found on the northern and southern sides of the Island. Thus we see the chief accumulation of this material exposed at Mahim and in Back Bay. It was seen exposed at the Light-house, along the shore of Pilot's Pier and constituting a part of the Colaba observatory compound. It was also found below the Esplanade, and some twenty feet below Dhobitalao area.

Upper Alluvium (*Lagoon Formation*).—It is the uppermost and most recent formation ; it is met with all over the 'Flats' in the centre, and salt-pans on the eastern side, of the Island. It is nothing more than the sea sludge, comminutted trap, deposited before the waters of the ocean were shut artificially by causeways and embankments from the region where it prevails.

During 1877 while the excavations for Prince's Dock were being made, the remains of what was evidently a submerged forest, about 32 feet below the high-water mark, were found. In 1910 during the construction of Alexandra Dock, fresh discoveries of a submerged forest were made ; the soil in which the trees were found rooted was at the depth of 40 feet below high-water mark. Thus it is apparent that the Island, subsequent to cessation of the volcanic activity, has undergone a series of subsidences and upheavals.

Within a distance of about four miles from east to west across the Island there is an area of elevation, proved by the existence in the centre of the Island of a sea-beach (12 feet above high-water mark) called Phipps Oart, near which no sea now comes ; and eastward in close proximity there is an area of recent subsidence—Prince's Dock and Alexandra Dock—proved by the discovery of a submerged forest. Sir Cyril Fox after considering this fact as well as the relative displacement of rocks on each side of the Island, concluded the existence of a north-south line of faulting (strike-fault) down the middle of the Island. Again it is possible that the fresh-water beds exposed on each side of the Island may, probably, not be identical.

Concluding Remarks

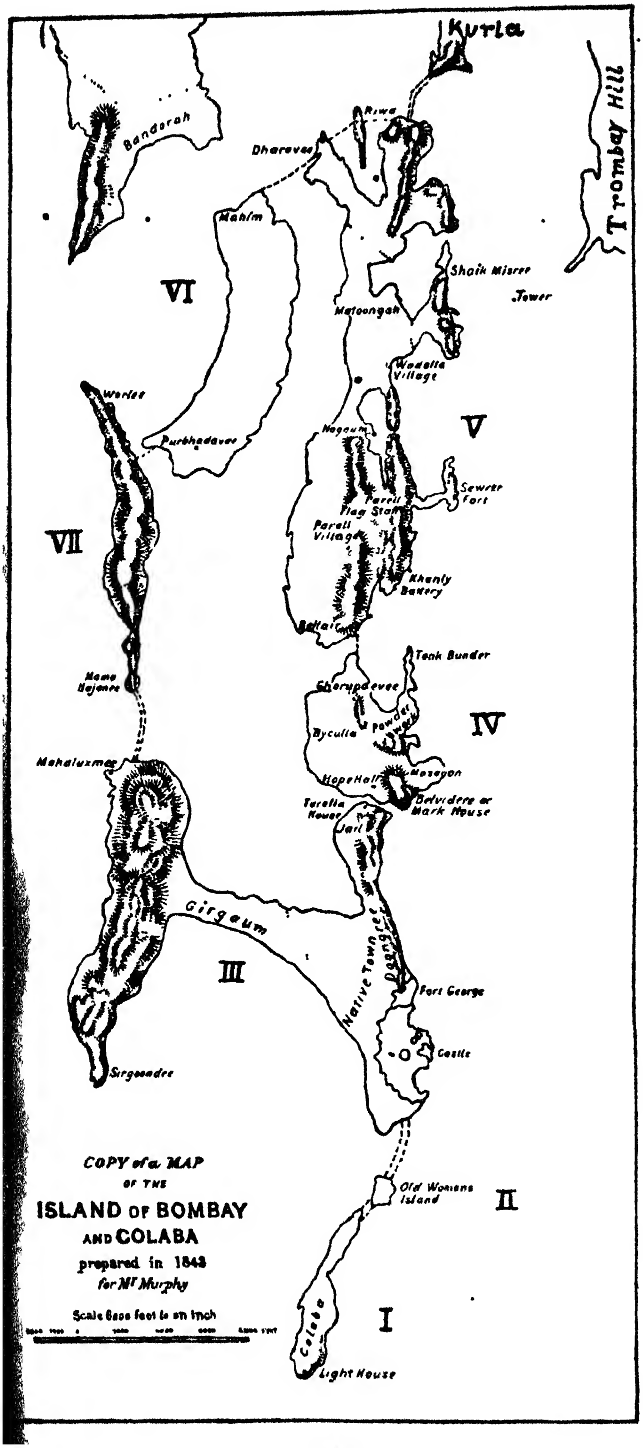
The rocks so far discovered in the Island are: acid rocks at Dharavi ; sub-basic rocks in the hills of the western ridges ; basic rocks in the hills of the eastern ridges ; ultrabasic rocks in the Trombay Hill ; volcanic ash and breccia in the Sion Hill ; Lydite-like rock in Antop Hill ; and the fresh-water lacustrine beds (Inter-trappeans).

The curious fawn-coloured acid rock ("White Trap") at Dharavi in the Bombay Island shows a remarkable similarity to that from Kharodiwadi. According to Das Gupta it may be the result of an effusive stage when the basaltic magma was passing to a phase more acid. It appears that at Dharavi is seen the southern representative of the series of acid rocks, which proceeding in a northward direction are again found at Kharodiwadi, Madh and as far as the hills of Uttan and Dongri in Bassein. Around the Trombay Hill (1,000 feet high), which is mainly of basalt, large masses of ultrabasic rocks are found in the alluvial flats near its northern boundary. In some wells in Trombay the presence of this ultrabasic rock was also noticed. However, this rock seems to occur as dyke-like intrusions in the basaltic hills in Thana and Kalyan.

A series of ultrabasic rocks (olivine-basalt, ankaramite and oceanite) is developed in connection with the plateau basalts. Mathur is also of the opinion that they appear to occupy a place complementary to that of the acid series. Here they appear to pierce the basaltic flows and, therefore, they indicate an age later than the Deccan Traps. Some rock analyses and microscopic examinations of the highest lava flow that caps Malabar and Cumballa Hills and also Pali Hill (Bandra), a continuation of the former, carried out in our Department, show that this trappean flow is an andesite.

Regarding the problem of the age of the Deccan Traps, some time back a new method of fixing the age by the determination of 'Lead-ratio' was contrived ; and for this purpose, Sukheswala, my former student and present colleague, has analysed in our Department about two dozen rock specimens. Our preliminary results gave enough encouragement and hope ; the method is now available for testing igneous rocks. Our investigations and results give an Oligocene age for the highest lava flows of Bombay, whereas the acid rock indicates a Pliocene age. These results are not at variance with the geological field evidence and palaeontological researches of Prof. B. Sahni and Prof. L. Rama Rao and his colleagues, and also the result of the 'Helium-ratio' of Pavagadh basalts (Baroda) by Dr. V. S. Dubey. Still many more analytical results are needed before full reliance can be placed on this new method of 'Lead-ratio', which gives promise of proving very useful in the determination of the age of the Deccan Traps.

The presence of acid, sub-basic, basic and ultra-basic rocks along with the volcanic ash and breccia and Lydite-like rocks on a small island like


Kurla
Trombay Hill
Bandorah
Riwa
Dharavee
Mahim
VI
Shaik Misree
Tower
Matoongah
Wadalla Village
Worlee
V
Nagoum
Purbhadavee
Sewree Fort
Parell Flag Staff
Parell Village
VII
Khanly Battery
Tank Bunder
IV
Byculla
Powder Works
Mahaluxmee
Mazagon
Hope Hall
Belvidere or Mark House
Tarella House
Jail
Girgaum
Native Town
Dongree
III
Fort George
Castle
Sirgeondee
COPY of a MAP
OF THE
ISLAND OF BOMBAY
AND COLABA
prepared in 1843
for Mr Murphy
Old Womans Island
II
Colaba
I
Light House

MAP I

this, shows that the Trappean rocks of Bombay are somewhat different from the average plateau basalt of the Deccan in their structure and chemical composition. With such a diversity of types of rocks occurring in Bombay, a careful and detailed study of the field relations of these rocks, along with their chemical, microscopic and palaeontological examinations, may possibly help to determine the genesis and chronological sequence of these different rock types. And for this a great deal more field-work will also be needed before the evidence can be adequately assessed and relied upon.

In this brief sketch of the Island I have confined myself mainly to combine the observations of most of the geologists, with what information I have collected, and to give a general idea of the existing state of knowledge about Bombay. All I have desired to do is to ventilate a subject of geological interest. The most that I hope for this Address is that it will ultimately stimulate further investigations in this fruitful and fascinating field of research.

Among contemporary workers nothing is more general than the frank admission that they are groping in a half-light, tentatively grasping what are, at best, only half-truths. And with every gain in knowledge we realise more clearly that we can never really know. From time to time we discover a fresh relation between observed phenomena. Our joy, therefore, in the search never fails ; we are constantly learning that it is better to travel than to arrive.

The literature on the various aspects of the subject discussed in this Address is scattered through several journals and papers, from which I have freely drawn. With such a vast field it has not been possible to cite all original sources of information or always to give due credit to those who by fact or idea have contributed to this many-sided problem.

I take this opportunity of thanking all those from whose publications and works I have derived the subject in one way or another. If, inadvertently, I have overlooked any courtesy in this respect, I trust that my apologies will be accepted. In the end, I thank you all for so courteously listening to me.

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SECTION OF BOTANY

President :—T. S. SABNIS, D.Sc., F.A.Sc., I.A.S.

PROGRESS OF BOTANY WITH SPECIAL REFERENCE TO ECONOMIC PLANTS

(Delivered on Jan. 5, 1944)

Let me first thank you for the honour you have done to me by electing me President of the Section of Botany for the year.

In my address I propose to deal with the recent progress in the various fields of botany with special reference to economic plants. Speaking of science in general we can say that its triumph in gaining for us the mastery over forms of life which minister to our needs is one whose magnitude very few of us realise. Since the beginning of civilization man has had a direct and vital interest in his food supply. He has, during centuries, made progress in improving the numerous plants and animals which have provided him with food, clothing and ornament. However, I should not be accused of indulging in astounding journalism when I say that during the last three or four generations the progress made has been greater than that made in the preceding several thousand years. No doubt the progress achieved by the non-scientific methods in those long centuries was good, but it could hardly have stood the strain of the modern political problems and helped to satisfy the industrial and commercial requirements of this age.

Living in a war-torn world in which increased production and utilization of economic plants and their derivatives call for as much industry, organisation and planning as do the other weapons of war, it is comforting to think how much botanists had already done even before the war clouds had darkened the horizon, and how much they continue to do which will be of benefit to the world when peace is restored. In the space of a brief address it will not be possible for me to do full justice to their achievements. I shall only outline in brief the outstanding work done in plant breeding and genetics, plant geography, ecology and various other fields of botany which directly or indirectly have been, or are likely to be, of practical importance now or in the brighter days that will follow.

PLANT BREEDING AND GENETICS

One of the first veteran workers who opened the eyes of the world to the possibilities of the science of plant breeding was Luther Burbank. If not a scientist, he was at least a scientific cultivator. In forty years his work had added hundreds of millions of pounds a year to the world's food production. He created nearly two hundred species of new fruits, vegetables, flowers and shrubs. His Burbank Potato and the edible spineless cactus for cattle have become history.

One of the most striking examples of scientific development of crops is that of sugar-beet. The original beet, cultivated in the days of the Greeks and Romans in Europe, had a dry and fibrous root. It was only in the latter half of the eighteenth century that the idea arose that the

plant could be used for extraction of sugar. The attempts made by growers for about a century to improve the sugar content resulted in causing the content to rise to seven per cent. It was then that science turned its attention to develop the sugar content still higher. In twenty years it had been doubled and in another decade almost trebled. In properly fertilized crops, examination of individual roots has given as much as twenty-seven per cent of sugar. This new source of sugar gave to the world an important industry and a variety of cheap food hardly equalled by any in the old days.

It is since the year 1900, when Mendel's paper disclosing his discovery of the fundamental laws of heredity was rediscovered, that the new science of modern plant breeding can be said to have originated. These laws are common knowledge now and it is needless to recapitulate them. One result to which they led was a fresh impetus with which work on most cultivated plants was taken up all over the world. The old varieties were subjected to selection and purification, new varieties tested and systematic efforts at hybridization started. The successful breeding of wheats in America closely following upon the creation of Marquis wheat, Biffen's breeding of Yeoman I and Yeoman II in England and Howard's Pusa wheats in India have now come to be regarded as landmarks in wheat growing in these countries. Most of the other important agricultural plants like barley, oats, maize, sugarcane, rice, linseed, cotton and tobacco have been subjected to breeding. In India along with wheat the crops to be subjected to breeding were cotton, rice and sugarcane. The work of Leake[40] on cotton, of Parnell and others[51, 52] and of Hector[23] on rice and of Barber[1] on sugarcane were followed by further genetical studies on these and other crops all over the country. Shaw and others[65] described inheritance in linseed, Rangaswami Ayyangar studied inheritance in various millets, Venkatraman and Thomas[78] succeeded in producing useful hybrids from crosses between sugarcane and sorghum. The investigations of Kadam[31, 33] on wheat, of Shaw and Bose[66, 67] on oats, of Ramiah [54, 55], Kadam[32] and of Sethi and others[63, 64] on rice, of Howard[25] and of Kashi Ram[34] on tobacco, and of Hutchinson[29] on cotton are a few of the many that have been carried out. Side by side work on selection and classification of important cereals like rice by Sethi and Saxena[62] and barley by Bose[5], and of oilseeds crops like mustards and safflower by Sabnis and Phatak[58, 59] was continued.

With the information which accrued on the genetical constitution of the plants and the behaviour of the different characteristics in inheritance, the hybrid instability ceased to be the bugbear which it was to the old breeders. Yet the newer knowledge could not supply to the breeder any particular system of selection which would ensure fixity of hybrids. It only provided him with a proper perspective of viewing his breeding problems, which, to say the least, is an important advance in the application of science.

The studies on inheritance led to the further discovery that inheritance was correlated with the number and structure of chromosomes and that the characters, whether structural or functional, were the result of actions of a number of living particles—the genes. The conception that the genes are the determiners in the development of hereditary characters and that they are transmitted through the chromosomes has been one of the most important revolutions of the biological science of the present century. It has offered explanation to many hitherto inexplicable phenomena and revealed many startling facts.

A generation of work on the new science of genetics began to leave an impression in certain quarters that the claims of genetics were exaggerated, and that "the existing varieties had been bred to such an extent that their possibilities were more or less exhausted, their desirable combinations had already been attained, though in many cases the ideal had not been fulfilled."[26] But there were workers who continued their endeavour and began a search for new genes. Among this band of workers the Russian plant breeders occupy a high rank. Under the leadership of Dr. I. N. Vavilov they have undertaken expeditions to different parts of the world to collect all possible species, cultivated and wild, which may be of interest to the country to supply food or various commercial commodities, such as oils, fibres, rubber, etc. This has added a new wealth of genes for increasing the agricultural resources of the country.

This aspect of Soviet research can best be exemplified by the work on potato. In 1923 the chief Soviet investigator decided that the potato breeders were working within very narrow limits. Consequently in 1925-28 the world's first potato expedition was despatched to explore Central and Southern America from Mexico to Argentine and to bring back as many varieties as possible. More than a thousand varieties, embracing thirteen related species of the potato, were collected although so far the world's potato breeding had been confined to a single species *Solanum tuberosum.* Many of the varieties possess useful qualities such as resistance to disease and cold. Evidently a complete programme of work is possible with such a rich collection although it may not be easy to get useful results in a short time. But like the other long-range programmes of the Soviet Government the research on this crop may also be fruitful.

The United States of America is another country which has been introducing useful wild and cultivated plants from all over the world. She maintains a Bureau of Plant Introduction which is entrusted with this work. From time to time expeditions are sent to the probable centres of origin in the various parts of the world to collect special crop plants and their wild allies.

Useful work in this direction is being done with potato in India. Several varieties of this crop, representing different species, were secured by Pal[49] from South America and these are being grown and subjected to breeding experiments at Simla.

The new introductions have, in some cases, been found to be naturally adapted to and suitable for cultivation in their new homes. Very often, though not so directly of use, they have provided useful material for synthetic breeding of new types by means of hybridization, thus giving rise to new and desirable gene combinations. The wild types have been specially useful in giving genes for greater hardiness and disease-resistance.

Along with the search for new genes attempts were made to discover new methods to combine them with the old genes. Hitherto attempts to hybridize different species or different genera had brought about little success, because even where the artificial fertilization resulted in seed development the hybrids produced were usually sterile. The discovery that a duplication of the entire chromosome set of the hybrid either in the germ cells or in the body cells produced fertile germ cells and progeny[27] opened up great possibilities for breeding new varieties and species through interspecific and inter-generic crosses. This duplication of chromosome sets has been brought about by means of X-rays and by treatment with colchicine[4, 53] and certain other chemicals.[38] One of the

famous intergeneric crosses is between wheat and rye. A still more interesting cross is that between wheat and couch grass (*Agropyrum elongatum*) made in Russia.[28] Several of the hybrids have shown resistance to rust and smut, with the addition of various other valuable characteristics, including high yield and perennial habit, giving promise of a perennial wheat with great hardiness which may be able to grow in regions where normal wheat varieties would fail.

Artificial induction of polyploidy is a new tool in the hands of the botanists for changing the plants. An interesting account of cytological work done in Sweden in recent years is given in Joint Publication No. 3 (1940) of the Imperial Bureau of Pastures and Forage Crops. The work consisted in systematic attempts to alter the chromosome numbers in crop plants in order that more valuable types for cultivation would become available. Among the findings described, those of Muntzung, who found that both auto- and allo-polyploid types as a rule are more vigorous in growth than the original types, are of particular importance to plant breeding.

Apart from differences in vigour and growth, there are changes in the chemical constitution some of which may be of great significance. Thus Sansome and Zilva[61] have found that tetraploid tomatoes have twice as much vitamin C as the diploid. Randolph and Hand[56] found a tetraploid strain of maize to contain 43 per cent more carotinoid per gram of dry meal than the corresponding diploid. Artificial induction of increase of the chromosome number may become a popular and standard method of increasing the nutritive value of plant products.

Experiments with X-rays and ultra-violent rays causing fertility in hybrids or mutations in different crops have also been conducted in America, India and Japan.

It is clear that along with such experiments the search for new and hitherto little known forms of plants must go on. Vast areas are yet unsurveyed for such plants. We have only to think of the great Himalayan forests, the wealth of species known to be occurring in China, the rich forests of South America and the reservoirs of wild life in the Soviet Union. In short, plant geography has to go hand in hand with plant breeding.

Plant Geography

As a matter of fact, plant geography is not a new branch of botany. Decades earlier, historic attempts to explore new species in distant lands had been made. With the publication of Darwin's *Origin of Species* in 1859 interest in exploratory and classificatory work had increased tremendously. Systematic botany came to the forefront of the study of botany. Much work was done not only in the field but also in botanical gardens, laboratories and in museums all over the world, and numerous voluminous 'floras' were written. India has produced a proud record of work in this field of botany. I need not go over this record. It was admirably presented to this Congress by my predecessor last year. The names of Roxburgh, Wallich, Griffith, Hooker, Clarke, Prain, Duthie, Gamble, Blatter, Fyson, Sedgwick, Almeida, Sabnis and Kashyap have become landmarks in the history of systematic botany.

Although the great vegetative zones of the earth have been described, the record is yet very incomplete. In many cases the record deals with the trees and shrubs, but the lesser forms, which nevertheless play big parts in the balance of life, have been left undescribed. Besides, only

the major zones in certain countries have been recognized ; there are still large, unexplored luxuriant rain-forests, where nature reveals herself lavishly, which have not yet been touched. Instead of completing the great task the botanists are drifting away from this work. What was done in the last decades of the last century was much more than what has been done in the present century. This paucity of work in systematic and taxonomic botany can be partly ascribed to two new developments. (1) With a closer and more intensive study of plants it has been found that among plants hitherto regarded as of the same species are found many varietal forms—or physiological and morphological varieties. The differences exhibited by them, in some cases striking, in others only small, may be of great importance, especially where the plant yields an economic product. Because, a particular variety may give the product in large quantities, while in other varietal forms the product may be present in small quantities or may not be present at all. Then also the different forms may show different responses to soil and moisture conditions. As a result it has now come to be recognized that the species of old can be differentiated into ecotypes or biotypes or micro-species whatever we call them. The interest of many systematic botanists is now directed to intensive study of work started by earlier botanists and to discovering the presence of these biotypes in the species described in the old floras. Thus the diminution of work in systematic botany is to some extent only apparent. These investigations are of great potential importance to both agriculture and forestry. They are being done in South Africa, Sweden, France and in England.[24] (2) The other factor which is responsible for a decrease in work in systematic botany is the increasing attention which many botanists are now paying to *plant ecology*—the virile offspring of the early plant geography—which deals with the study of plants in their natural homes and is concerned with the effect of the environment upon the plant.

Plant Ecology

It is clear that if we are to make use of our knowledge of botany for solving problems of plant production, whether in botany, agriculture, horticulture or forestry, we must be familiar with the effects which the various environmental factors like light, moisture, temperature, soil, associated plants, etc., produce upon plants. In other words, unless the relationships between the plants and their habitat are clearly understood we cannot well solve our problems. Although the floras of the past include in many cases a short account of the habitat, they do not discuss the relationship between the plants and their habitat. The accounts are merely descriptive. Plant ecology aims at not only describing the finer details of plant distribution but also elucidating the origin, development and structure of vegetation. It further seeks to study plants as individuals and as communities, to trace their succession, aggregation, migration and ecesis and to describe the competition between species. It is not merely descriptive (although much of its work is still in the descriptive stage), it is an experimental science, a "higher physiology" in which the systematist, the physiologist and the agronomist have a common meeting ground. It is by considering that vegetation in an area is subject to developmental changes, that it is dynamic, that we can properly study and classify it. This view expressed as early as 1910 by Moss[45] and later emphasized by Nichols[47], Tansley[71], Dudgeon[16,17], Sabnis[58] and Clements[11,12] appears to be a logical one and has been useful in giving

to the study of ecology a sound and scientific basis. The work of Clements has been specially notable in this field of botany. His work on and conception of climax, succession and conservation have led workers to investigate the fundamental laws concerning the growth of plants in relation to the various environmental factors. It is needless to add that when we are dealing with the problem of controlling vegetation for our use the conception of succession and conservation as elaborated by Clements will be of infinite help. It will find use in problems of improvement of grassland and conservation of vegetation. A recent Imperial Bureau Bulletin[81] summarises the work done on grasslands and forage crops and on conservation of vegetation in the United States of America, and emphasises the importance of Clement's work. It has been found that of the three factors, water, light and nutrients, the first is most important qualitatively whereas the effect of the latter two is mostly quantitative. Of late much attention has been paid to the *light* factor in the study of vegetation zones, leading to important discoveries on photoperiodism.

Photoperiodism

Photoperiodism is the phenomenon of the response of the plants to the period of light (or length of day) for the development of flowers and seeds. It is to two American botanists Garner and Allard[18,19,20] that we owe some important information on photoperiodism. Their work evoked much interest in the subject and led to intensive studies of many plant species in the different parts of the world. According to the information available, plants can be divided into three groups according to the daily length of light which they require for flowering. (1) "Long day plants" which need more than twelve hours' light for successful flowering ; (2) "Short day plants", which flower only if they receive less than twelve hours' light per day ; (3) "Neutral plants", which are unaffected by change of light periods.

Long day plants require long days for flowering although they make vigorous vegetative growth during short days.[72] Typical examples are the potato, spring varieties of temperate zone cereals, garden pea, etc. Short day plants, among which we find tobacco, maize, subtropical cereals, chrysenthemums, dahlia, cosmos and other diverse species, continue to develop only vegetatively under a long day illumination. They would come into blossom only under short day illumination.

Among the neutral plants are many species and varieties of the tropics. They are not materially influenced in time of flowering by the length of day.

Advantage has been taken of this response of plants to light in breeding experiments. The American breeders grew cereals in green houses in winter and used artificial light to supplement natural daylight and succeeded in growing to maturity three successive generations of wheat in one year.[22] Russian workers have made experiments at Takshkent on the photoperiodism of the cotton plant, subjecting different varieties to daily illumination of 6, 9 and 12 hours against the average of 14 hours of the controls growing under normal conditions. Different varieties were found to show different hereditary reactions. The general effect of shortened illumination was an earlier production of flowers and bolls. By subjecting different varieties to various amounts of illumination it was possible to synchronize the flowering of widely divergent varieties and species and thus cross-fertilize them where, under normal

conditions, such crossings would have been impossible, because of the difference in their flowering seasons. Thus crosses were made between Egyptian cotton with low boll weight and several South American cottons with large bolls but of short day and perennial habit.[28] Such 'light' treatments have been used by the Japanese for rice breeding and are finding use in India also for potato breeding at Simla.[50]

The information secured on photoperiodism will be invaluable to the agriculturist and the horticulturist for raising plants in new environments, different from those to which the plants belong.

VERNALIZATION

The response of plants to temperature is not less marked than that to light. It is directly concerned with nearly every function of the plant. Its effect on chemical processes such as diffusion, precipitation, cell-wall formation, etc. have been the subjects of study in different laboratories. Temperatures, maximum, minimum, optimum and favourable and unfavourable to plants and their relation to growth have been studied. In order to apply the information to crop cultures attempts were made for many years to determine the total of the effective heat units necessary to grow the various crops to maturity.[35] As a result it was proposed to define crop growing zones such as the spring wheat belt, the winter wheat belt, the cotton belt and so on[36, 60], because the temperatures of the growing season alone were found to limit the growth of these crops.

It was for Lysenko, the young professor in Russia, to show in 1932[82] that it was possible to triumph over nature's climatic barriers by subjecting the seed to certain temperature treatments. The treatments consisted in subjecting the developing embryo, still within the unbroken seed coat, to particular sets of temperature for definite durations. The process of giving the required treatments is known as *vernalization*. It is based upon a theory of plant life enunciated by Lysenko, the main features of which are:—Growth and development of the annual plant are independent phenomena. The conditions required for growth may not be the same as those required for development. The development consists in a series of stages, each of which requires a definite set of external factors such as light, heat, etc. Unless one stage is completed the plant will not enter the succeeding stage. The first stage, recognized by Lysenko, is the thermostage, which is a temperature stage, and unless this is completed the plant will not start on its second stage of development, although it may continue to grow (*i.e.*, exhibit vegetative growth of stem, roots and leaves) without flowering and setting seed. Thus certain varieties of wheat when sown in spring were found to grow well and tiller profusely but failed to flower and set seed. When vernalized, the seed gave crops which proceeded to ear normally and ripened before the onset of winter. According to Lysenko, the prolonged vegetative period was due to the fact that the seed missed the right thermostage after it had been sown, with the result that the next developmental stage, *viz.*, the reproductive stage, could not occur. The seed, when given the right thermostage, which consisted in subjecting it to low temperatures, gave normal crops. As a result, many varieties of winter wheats which would not ear when sown in spring were, through vernalization, made to yield good crops. The climatic barrier was thus broken and the zones for winter and spring wheats merged together.

The treatment is given before the seed is sown. In many cases vernalization shortens the growth period which is a very important

consideration for areas with short seasons. Such areas are extensive in Russia, for example, the Ukraine where late spring thaw is followed after a short favourable season by high summer temperatures and draught. So also in the "frozen north" the short summers sandwitched between long icy winters made wheat cultivation impossible until vernalization, by shortening the period between sowing and harvest, made these areas productive.

The work of Lysenko and his school stimulated a great deal of interest in vernalization all over the world and experiments were started not only in Russia but also in other countries. In the Russian experiments on cotton not only higher yields but also increase in lint length were obtained. The best results were obtained by keeping the moistened seed at a temperature of 25° to 30°C for varying periods. In the American cottons vernalization produced a tendency to higher ginning percentage and length of lint, but in the Egyptians the ginning percentage was increased while the lint length was slightly decreased.[26] The flowering period was reduced by 3, 4, 9 and even 13 days. Vernalized sowings were made on a large scale on collective farms. In other countries the work is still in the experimental stage, no large scale commercial sowings of vernalized seed yet having been taken up.

Apart from being of economic importance, vernalization has become a subject of academic discussion. By changing the very response of the plant to its environment it has struck at the foundation of the breeder's idea of plant "characters". What significance can therefore be attached, for example, to inheritance of earliness when "earliness" itself is not a definite character or property of the plant?

When first propounded, Lysenko's theory of plant life appeared staggering as it ran counter to the established notions of the breeder and the physiologist about plants. Now the facts do not appear to be so staggering, although they are not simple nor have they been adequately explained. What is surprising is that they took so long to attract the attention of the scientists when it was long known that low temperatures are necessary for many plants to enable them to complete their life cycles. As early as 1920 Coville[13] observed the influence of cold in stimulating the growth of plants. Lysenko's vernalization of winter wheats by subjecting the soaked seed to freezing temperatures was just the application of this principle for stimulating development.

Growth Hormones

Talking of stimulating influences reminds me of the discovery of the role which "growth hormones" play in stimulating growth in plants. This discovery was the outcome of the study of "tropisms" in plants by Boysen-Jensen[7,8], Paal[48], Stark[70] and Bruner[9], who worked on the growth of coleoptiles of various Gramineae and their response to light. These workers demonstrated that the response was due to some substance or substances produced at the tip which, by diffusion into the tissues below, caused the curvature of the coleoptile toward light. It was Went[80] who, in 1926, definitely established the existence of the growth substance. His work was the starting point for a worldwide investigation into the problems of growth and the chemical nature of the substances promoting it.

In analogy to hormones which had been discovered earlier in the animals, the growth substances of plants are popularly referred to as plant hormones. Some workers have preferred to call them growth regulators.

It was found that, like the growing shoot tips, roots were also controlled in their growth by a hormone. The Boyce Thompson Institute for Plant Research in the United States of America, has devoted considerable attention to the root-growth promoting substances and discovered that various chemicals, like indole acetic acid, phenylacetic acid, napthalene acetic acid and their esters, promote root growth. We are indebted to Zimmermann and Hitchock[84] for work of much value. In 1935 they discovered an economic use for these hormones. They used them, mixed with lanoline, for coating stem cuttings of garden plants and thus inducing them to root where earlier attempts, without the use of hormones, usually resulted in failures. In cases where rooting of cuttings proves difficult or in the case of seedlings which are too delicate and suffer considerable mortality in the early stages it is suggested that the use of hormone coatings or preparations of the growth promoting chemicals can be adopted with benefit. Their use is, however, not simple. It may vary with the species and varieties of plants used, with the type of cutting or the age of seedling used, with the temperature of the air or the rooting medium and with the condition of the other environmental factors. Although some proprietory products such as "Auxilin", "Seradix A", "Hartomone", etc. have been brought out, their use has not led to infallible success. A great deal of work requires to be done on the factors stated above before the practice of using the substances in horticultural and plant breeding work can be standardised.

Recently considerable interest has been evident in the problem of stimulating the germination of seeds and the growth and the resistance of seedlings to diseases. The work of Youden[83], Hwang and Pearse[30], Barton[2, 3] and Croxall and Ogilvie[14] shows that the results of hormonisation are not uniform and that the particular requirements with regard to condition of seeds, their species, environmental conditions, the concentration of hormones used have yet to be worked out before the method can be adopted as a standard practice.

The discoveries by Kögl and Kostermans[37] of hormones yielded by the fungus Rhizopus and Yeast have added to the interest on the subject. The latter worker reports that by soaking seeds of plants in a solution of the hormone he caused the plants to flower and to reach maturity earlier than the plants from untreated seed—an effect similar to that brought about by vernalization.

It is not unreasonable to speculate that the effect in both the cases is due to increased enzyme activity. Demkovsky has studied the enzyme action occurring during vernalization and found that there was both a general increase of enzyme activity and also a change in the interrelation between different groups of enzymes.[82] The biochemical aspect of vernalization and of the effect of plant hormones opens up a new field of inquiry, adding to the interest which was created in the last century in the chemistry of living plants and which received impetus from the vast developments in chemical research in industry in Germany.

Rôle of Secondary Elements

It is the German scientist Liebig, who established, towards the end of the last century, that plants require the necessary elements, carbon, nitrogen, hydrogen, oxygen, phosphorus, sulphur, potassium, magnesium, calcium and iron. Based on his work numerous investigations have been carried out during the last few decades on plant requirements and on the effects produced if an element is withheld or given in excess.

More recent still is the discovery that the above elements, considered to be able to satisfy all the requirements of plant growth, do not exhaust the list of elements which can be considered essential. There are some others which are also essential but which are required in only minute quantities. For example, Warington[79] showed in 1923 that the broad bean, *Vicia Faba,* only attained full development when grown in the presence of a trace of boron and that no other element could replace it. Sommer[69] found that other plants, such as maize, peas, sunflower, vetch, sugar beet, sorghum, flax, mustard and pumpkin also require boron. Similarly manganese was found by McHargue[42] to be essential for the growth and development of maize, onion, cucumber, lettuce, wheat, spinach, oats, tomato and peas, and he considered it to be of equal importance to iron in the formation of chlorophyll. Silicon has also been found to be of importance in plant nutrition[68]. It benefits the plant by causing an increase in the assimilation of phosphates by the plant. For some plants zinc has been found to have an important function.

As soon as the role of these "secondary elements" was recognised practical use was made of the knowledge. Vast crops of turnips, swedes and sugar-beet could be saved by supplying the boron deficiency. In California orange trees suffering from pale, malformed leaves are sprayed with compounds containing small traces of zinc, and the later-formed leaves are healthy and of normal colour.

Hydroponics

The above findings were, in many cases, the results of laboratory experiments with water or sand cultures which were made to contain the different chemicals and which were altered in constitution at will in order that the effects of one or more constituents be studied individually and collectively. Although these cultural studies were of great agricultural interest and have been practised for about a century, it was not till very recently that soilless crop production (or *hydroponics* as it is called) was developed. The earlier studies aimed at making better use of the soil. It was in 1929 that Gericke[21], the pioneer worker on hydroponics, presented the theory underlying soilless crop production and pointed out that "crop production need no longer be chained to the soil, that some commercial crops could be grown in larger quantities without soil in basins containing solutions of plant food."

Hydroponics is still in the experimental stage. Although it has given extraordinary results, giving yields far outstripping those obtained from the best farm lands, it presents many problems which have to be solved before it can be adopted as a scientific practice. First it is necessary to supply the proper food elements through a well-balanced solution. Then the questions of giving to the growing crop the proper amount of light and heat, avoiding overcrowding, preventing fungus and insect pests and making the whole thing an economic proposition, need thorough investigation.

Plant Diseases

To increase the production of economic plants the contribution of botanists to fight plant diseases has not been any less remarkable than in other fields. The Great Famine in Ireland, caused by the failure of the potato crop due to the Potato Blight fungus, which wiped out a large portion of the population of that predominantly agricultural country,

was not allowed to recur. Not only are essential food plants like potato, wheat, turnip, cabbage, tomato, etc. subject to devastation by fungoid attack, but also many ornamental plants like the tulip, the daffodil and many other popular flowers are liable to suffer inestimable damage from the fungi. In the tropics important plants like tea, coffee, rubber, banana, sugarcane and trees yielding timber grow under conditions almost ideal for the development of the fungi and are always menaced by them. From every part of the world come reports of damages done by the fungi and the accounts of their life histories and the different forms of the causal organisms. In India outstanding work has been done by Butler[10] in a pioneer attempt to describe the fungus diseases of the plants in the country. This has been followed by a more intensive work on some of the important fungi, for example, work on wheat and barley rusts by Mehta[44], root diseases of cotton by Vasudeva[75, 76, 77] and by Kulkarni and Mundkur[39] and on loose smut of wheat by Luthra and Sattar[41].

One way of fighting the diseases is by checking the fungus organism by the simple method of spraying with fungicides, mostly based on copper or sulphur. This has been found specially effective on fruit trees, vines and vegetable culture. Another method is that of soil treatment. Thus the "take-all" disease of wheat which is the chief enemy of the Australian wheat grower, has been found to be connected with soil acidity. In America root disease of tobacco has been found to be related to soil temperature, and growing the plants slightly above or below what would otherwise be the best temperature can result in reduced fungal attack. The most striking and, to the grower, the most convenient method is that of growing resistant or immune varieties. In the United States, in Canada, India and other countries great success has been achieved in breeding rust-resistant individuals from existing varieties or by recombining resistance with other desirable qualities by artificial hybridization. Scientific breeding for disease-resistance by hybridization was first started by Sir Rowland Biffen in England about a generation ago and is now being followed in different countries. In India Mc Rae and Shaw[43] have bred varieties of pigeon pea (*Cajanus Cajan*) highly resistant to wilt. Mundkur, Pal and Bose[6, 45] have studied varietal resistance of Indian and other wheats and oats to smuts, and Uppal[74] has worked on resistance of cotton to wilt.

Besides the fungus other great enemies of plants are the bacteria and the viruses. Prophylaxis in plants unlike in animals by injection or vaccination is out of question. Here the introduction of new resistant varieties is the best method of checking the disease, as was done in the case of sugarcane in Louisiana.

Efforts have been made to shift the balance of fungal or bacterial population in the soil with a view to benefiting the plant by introducing a fungus which is antagonistic to or which comes into competition with "bad" fungi. This has so far been tried on a laboratory scale with actinomyces and the work is at present in abeyance.

CONCLUSION

Thus the work of the botanists in increasing the geographical range of crops, discovering new and suitable varieties, studying their relation to soil, temperature, light and moisture, improving their yields, reducing the cost of cultivation, securing immunity from diseases—all this work must go on. Overproduction, the terror of the economists, need not worry us, because even if it is there, it should not call for a curtailing

of the activities of the botanists. An official report wisely suggests: "When farm production exceeds the demands, it should be reduced, not by discarding science, but by planting fewer acres and raising fewer animals. There is no advantage in allowing costs per unit of production to increase, as would be the result of giving science a holiday."

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SECTION OF ZOOLOGY AND ENTOMOLOGY

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THE GOLGI APPARATUS

(Delivered on Jan. 4, 1944)

INTRODUCTION

My first duty is to thank the Indian Science Congress Association for nominating me as President of the Section of Zoology and Entomology. I greatly appreciate the honour.

Since many reviews of the Golgi apparatus have been published recently (Cowdry '24, Nath '26, MacBride and Hewer '31, Kirkman and Severinghaus '38, Hirsch '39 and Bourne '42, etc.), it will be superfluous to write another on the subject, even if I had been fortunate enough to have the necessary facilities and space at my disposal in these days of general scarcity. My intention, therefore, is not to assume the rôle of a reviewer who must necessarily go through all the details of the subject in the stereotyped manner ; but to make an attempt to interpret the numerous available publications, often conflicting, in the light of my own observations and to try to evolve some order out of the seeming chaos. If, while going through the intricate ramifications of this highly controversial subject, I make a statement which is not quite in accord with facts, I shall be grateful if my attention is directed to the error.

HISTORY

It is now more than forty years since Camillo Golgi (1898), the celebrated Italian neurologist, discovered an 'apparato reticolare interno', the Golgi apparatus, in the nerve cells of certain mammals by means of his 'reaziona nera' or black reaction, which appears after suitable treatment with silver nitrate. For many years after this epoch-making discovery cytologists were content with the study of the mere srtucture of the Golgi apparatus, and it is only during the last fifteen years or so that some attention has been paid to the chemical composition and functions of this important cell component.

Soon after the discovery of the Golgi apparatus Holmgren ('02) attempted to homologise the apparatus with a system of clear canals ('trophospongium'), which he had observed in certain cells. Cajal ('08) confirmed the homology and actually referred to Golgi's reticular apparatus as Golgi-Holmgren canals. The separate identities of the Golgi apparatus and Holmgren's canals had hardly been established when Parat and Painlevé ('24) created a veritable sensation by announcing the now well-known 'vacuome-Golgi apparatus' hypothesis.

According to the vacuome theory all animal and plant cells have only two kinds of living cytoplasmic components—the vacuome and the chondriome. The vacuome is an aqueous phase and consists of vacuoles having an acid reaction, which stain specifically with the vital dye, neutral red. The chondriome is the lipoidal phase and consists of mitochondria, which stain specifically with the vital dye, janus green.

According to Parat and his followers the classical Golgi reticulum was an artifact formed by the excessive precipitation of silver or osmium not only on the surface of and inside the vacuoles but also in the narrow spaces between them. Later Parat introduced two new terms, the 'lepidosomes' (modified mitochondria) and 'chondriome actif' (active mitochondria), to include the argentophile and osmiophile dictyosome, which often formed the cortex of the round chromophobic substance in the case of discrete Golgi bodies showing a duplex structure. The 'chondriome actif' was thus occasionally associated with the chromophobic substance which, according to Parat, was the vacuome.

In France and elsewhere in Europe the vacuome theory was accepted without any reservations by a host of workers, but in Great Britain, America and in this country it was received with scepticism. Nevertheless, like all theories, it stimulated a considerable amount of valuable research. Gatenby ('29),[1] working on the male germ cells of *Cavia*, *Helix* and *Abraxas*, observed that Parat's vacuome theory was unsound. According to Gatenby, 'the vacuome is not the Golgi apparatus, but the associate or derivative of the Golgi cortex, and the dictyosome is not a modified mitochondrion as suggested by Parat, but is a separate and characteristic structure'. The work of Miss A. G. Hill in his laboratory on the oogenesis of *Daphnia* convinced Gatenby that 'the Golgi element is a cortex on the vacuole and the division of the element brings about a division of the associated vacuole'. It is thus clear that Gatenby considered the chromophobe substance often associated with the Golgi element as the homologue of the neutral red staining vacuome of Parat, and the 'lepidosome' of the latter as the homologue of the dictyosome (the classical Golgi material).

Nath and Nath and his collaborators (see Nath '33 for references), working on the oogenesis of several forms, also interpreted the chromophobe substance of the Golgi element as the vacuole, but they recorded in all cases their complete failure to stain this substance with neutral red. Only in the case of the cockroach (Nath and Piare Mohan, '29) did neutral red stain the Golgi vesicles very slightly. That the chromophobe substance of the Golgi vesicles was not the neutral red staining vacuome of Parat, at least in eggs, was finally proved by Nath ('31) and Nath and Nangia ('31), who demonstrated prominent watery vacuoles, vesicular Golgi bodies and granular mitochondria as independent cytoplasmic components in the fresh eggs of the common Indian frog (*Rana tigrina*) and teleostean fishes (*Ophiocephalus punctatus* and *Rita rita*). In all these forms the vacuoles (which are stainable with neutral red) and the Golgi bodies (which are not tinged even slightly with the fat dyes, Sudan III and Scharlach R) can be seen *intra-vitam* without the aid of any vital dye or osmic acid with diagrammatic clearness. I recommended this material to the most sceptical. In other words it was proved that the chromophobe substance of the Golgi element was not the homologue of the neutral red staining vacuome of Parat.

At Allahabad Professor Bhattacharya ('29), who had worked with Parat in France, demonstrated, in collaboration with Dr. Das, that in the young oocytes of the pigeon the vacuome and the classical Golgi apparatus were independent cell components.

In the somatic cells likewise it was shown, chiefly by the studies of Chlopin, Beams and Ludford, that the chromophobe substance of the

[1] In this paper Gatenby gives a useful review of the earlier work of Hirschler, Monne, Karpova and Voinov on the male germ cells of certain forms.

Golgi apparatus was not the neutral red staining vacuome of Parat, which was quite independent of the Golgi apparatus. The position in these cells may be summed up by a quotation from Beams and King ('32): 'Therefore, it would seem from the foregoing facts that the neutral-red bodies in our material are quite separate from the Golgi apparatus, notwithstanding the dogma of Parat and his followers. This conception is, for the most part in agreement with the studies of Nassonov ('26), Chlopin ('27), Alexenko ('30), Ludford ('30, '31), Beams ('30, '31), and others, *i.e.*, that the neutral red bodies observed simply represent new formations in the cell, either by the segregation of the injected neutral red into droplets or by the accumulation of waste products in the cell which are readily stained by neutral red. Just how this phenomenon is accomplished is still a debated question'.

In plants likewise Bowen ('27 and '28) demonstrated in several kinds of cells, including representatives of both germinal and somatic tissues from the Bryophyta, Pteridophyta, and Spermatophyta, the existence of osmiophilic platelets which, to say the least, much more nearly conform to the classical lipoidal Golgi apparatus of the animal cell than the vacuome. Bowen's extensive researches on the plant cells were soon confirmed by Patten, Scott, and Gatenby ('28).

We must not, however, jump at the conclusion that the vacuome is always an artifact, representing new formations in the cell, either by the segregation of the injected neutral red into droplets ('crinome' of Chlopin) or by the accumulation of waste products in the cells which are readily stained by neutral red. On the contrary, watery vacuoles are very real structures and are developed at best in such cells as the plant cells (Dangeard and Guillermond), Heliozoa (Schaudinn) and the oocytes of *Rana tigrina* and certain teleostean fishes (*vide supra*). Indeed I believe that the existence of vacuoles in the cytoplasm (homologies apart) is the *sine qua non* of the metabolic activity of protoplasm, as in the interior of these vacuoles various substances such as aleurone grains (Guillermond), acrosomal granules (Bowen, '20, '22 and '24 ; and Gatenby and Woodger, '21), fat (Nath and Gresson, '29 and '31), protein yolk (Hibbard, '28 ; Hibbard and Parat, '27 and '28 ; and Nath and Nangia, '31), and secretory granules (Duthie, '34 and Hirsch, '39) are gradually condensed and ultimately become mature.

Parat and his followers, therefore, deserve to be congratulated on focussing attention on a very important cell component, even though their homologies have been shown to be erroneous.

Technique and Morphology

The form under which the Golgi apparatus may appear in a given cell depends entirely on the technique employed. So closely are technique and morphology of the apparatus bound up with each other that many cytologists (even experienced ones) have been completely led astray. Consequently there exist in the literature numerous bizarre descriptions of the morphology (and functions) of the apparatus. Nevertheless it is not my intention to outline the various methods[2] for the demonstration of the Golgi apparatus, but I shall refer to some of these only indirectly in so far as a particular method is or is not likely to cause artifacts.

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[2] These have been set forth in great detail by Bowen in six papers, all published in 1928

MacBride and Hewer ('31) describe the Golgi apparatus 'as a plate or network in the form of a ring, disc or cylinder, in which case the apparatus is continuous except during times of metabolic activity, when it may become irregularly fragmented and distributed throughout the cell. In other forms it occurs as individual elements, either collected into one definite locality or else scattered in the cytoplasm. Although modified cytoplasm, known as idioplasm, is normally only found to accompany the apparatus in germ cells, it is also probably present in all cells, although not demonstrable. This idioplasm is situated on one side of the fixed Golgi elements, these appearing either as platelets or batonettes (rodlets). A secretory granule or vacuole may occur within the idioplasm, and it has been suggested that the real situation of the osmiophilic Golgi is as a sphere round the idioplasm with its vacuole. This is probably incorrect, as it does not fully take into consideration the platelike form of the Golgi apparatus unless the sphere is envisaged as incomplete. It is doubtful whether this would form a stable system, although it is not impossible'.

According to Kirkman and Severinghaus ('38) the Golgi apparatus 'has been described as a fibrous reticulum, network, ring, or cylinder, a very irregular fenestrated plate, a more or less incomplete hollow sphere, vesicle, or cup, a collection of small spheres, rodlets and platelets or discs, a series of anastomosing canals, a group of vacuoles, and a differentiated region of homogeneous cytoplasm crossed by irregular interfaces'.

What a bewildering variety!

But Baker ('42) goes to the very root of the problem and makes the following most pertinent and refreshing comment: 'It may be remarked that no one knows what structure the ideal technique should show. The Golgi network is often spoken of, but it may be queried whether this is often a good description. If such a thing could be constructed as a true model of the complex, magnified several thousand times, and if this model were shown to a member of the general public, it is possible that he would compare it to accumulations (or rows) of spheres embedded in a slimy looking material, or to spheres with bananas adjacent to them or touching their surfaces, or to spheres with separate strings intertwined among them, *or even in some cases—if one may dare to suggest a heresy —simply to spheres* (italics mine) ; but the writer is doubtful whether the word network would often be used to describe the model, though it might occasionally be applicable'.

Why is it a heresy to compare the Golgi elements to spheres? Is it because the 'sphere' does not fit into the secretory hypothesis of the Golgi apparatus advocated by a powerful and influential school of cytologists—a school who have ever been insisting on the 'dictyosome', 'batonette', 'rodlet', 'banana' or 'crescent' form, which, I firmly believe, is an artifact (*vide infra*)? But I must first talk of the Golgi net.

For many years since the discovery of the 'apparato reticolare interno' by the silver method, nobody seems to have questioned the validity of Golgi networks. The various modifications of the original silver method employed by Golgi were followed by the long osmication methods, which are, at best, only slightly less unsatisfactory. There is no doubt that the Golgi material has a marked affinity for silver and osmium, and further it has been made abundantly clear that the Golgi elements are often held in chains or are closely aggregated in a juxta-nuclear position. When silver nitrate or osmium tetroxide is reduced to metallic silver or osmium respectively, the reduced particles seem to come down like a shower and are deposited not only on the surface of and in the interior

of the Golgi elements, but also in the narrow spaces between them. The result is a network! This is more easily produced in nerve cells than in other cells, as the protoplasm of the former is known to be a gel. The production of a Golgi 'net' by Singh and Boyle ('38) in the fish egg with the Aoyama method is only one of the many glaring examples (see Nath and Nangia, '31 and Nath, Bharpur Singh and Abu Bakr, in press).

It is pertinent to ask: Have ever Golgi nets been demonstrated by methods not involving reduction of silver nitrate or of osmic acid for long periods? To the best of my knowledge they have never been. On the contrary, various miscellaneous methods (*e.g.*, Champy or Flemming-without-acetic and iron-hæmatoxylin) have invariably demonstrated discrete Golgi elements in a large variety of cells. I have never observed any nets in the course of my studies on male and female germ cells of various animals, even in silver and osmium preparations; and I have always doubted the validity of the reticulate structure of the Golgi apparatus. Contrary to the findings of previous workers, Beams and King ('32) have demonstrated discrete bodies in nerve cells. According to Bourne ('42), Hirsch ('39) 'denies the existence of most networks and other workers have regarded them as staining artefacts'. Hirsch has actually described discrete granular Golgi bodies in the living acinar cells of the pancreas of the mouse, and he regards, according to Bourne, descriptions of a Golgi net in that material incorrect. Duthie ('34) has likewise described discrete Golgi bodies in the Harderian gland of the rat. More such examples could be cited.

It is of interest to quote from Bourne ('42): '. . . . . grains of silver seem to be composed fundamentally of a network structure. The granules of silver in a photographic emulsion even under the high power of the ordinary microscope appear to be homogeneous, but when they are examined with an electron microscope, magnifying them by 25,000 diameters, they may be seen to be networks, made up of threads, some of which are only five atoms thick (Plate 2, Fig. 2). The type of network can be varied according to the developer used. Hydroquinone produces coarse threads, whereas metol produces fine threads. With some other developers the network becomes a sort of fluffy mass. The form of the Golgi network also varies according to the time of development and the type of developer used'.

It is significant that nobody has ever succeeded in demonstrating Golgi nets in the living cell. On the contrary, Kite and Chambers (Cowdry, '24), in their microdissection studies on the vertebrate cells, did not encounter any 'areas of resistance suggestive of the presence of a rigid network'; and further, movements were produced in the cytoplasm when the cells were carefully crushed. Although it is impossible to accept Strangeways and Canti's ('27) complete denial of the Golgi apparatus the fact remains that they failed to observe any net in the living tissue culture cells either by direct or dark ground illumination. Ludford's ('27) explanation of the failure of these observers to see any Golgi nets in cultured cells, (*viz.*, 'as some cells spread out the Golgi apparatus is stretched until it fragments and its individual particles become dispersed in the cytoplasm'), only serves to emphasize the artificial environment in which such cells are made to live. Similarly the remarkable experiments of Walker ('28) and Walker and Allen ('27) tend to show that Golgi nets are artifacts, although we cannot agree with them that the Golgi apparatus is altogether a coagulation phenomenon. We have also to note that ultraviolet light photographs of living unstained cells have failed to show any Golgi nets. The Golgi net photographed

by Ludford ('35) in living tissue culture cells stained *in vitro* with methylene blue is undoubtedly a juxta-nuclear mass of closely aggregated granules.

For similar reasons I regard the dictyosomes, batonettes or rods not associated with any chromophobe material as artifacts formed by the alignment of Gogli elements, which are essentially granular. This phenomenon has been discussed in detail by Nath and Bhatia (in press) who, working on the centrifuged oocytes of the earthworm, have considered the rods, figured by Norminton ('37) and Singh and Boyle ('38) in the oocytes of the earthworm and the stickleback respectively, as artifacts.

I have always looked with scepticism on accounts describing the Golgi element as a dictyosome or a rod ; and some preparations by Gian Chand (one of my M.Sc. students) of the spermatocytes and spermatids of *Cavia* made with Flemming-without-acetic have clearly demonstrated that the large dictyosomes figured by Gatenby and Woodger ('21) at the periphery of the idiosome are indeed artifacts. The real form of the Golgi elements in this material is granular, but the granules are so much over-crowded at the periphery of the idiosomic body that they appear as dictyosomes in the Cajal and Mann-Kopsch techniques employed by the authors. Indeed Meves (1899) in his classical work on this material actually figures granules (and not rods) in the idiosomic body.

My doubts about the reality of the dictyosomes were raised several years ago when Bell ('29), using a new technique on the spermatid of the dog, demonstrated small osmiophile granules embedded in the idiosome. To quote Bell: 'These granules are undoubtedly the homologue of the Golgi apparatus described for the guinea-pig by Gatenby and Woodger ('21), but at no time do they assume a crescentic shape like those of Cavia'.

The conclusion, therefore, is unavoidable that Golgi nets, dictyosomes, batonettes and rods are all artifacts. The question now arises: 'What is the crescent, sometimes thick in the middle and tapering towards the ends, holding in its concavity the round plate-like mass of a chromophobic substance'? The plain answer is that it is the optical section of a Golgi sphere having a duplex structure, with a thick chromophilic cortex and a chromophobic core. Harvey ('27) and Nath ('30) gave this answer several years ago. In spite of Harvey's retraction I am now confirmed in this view after my prolonged studies on the Decapod sperm ('42), where ring-shaped centrosomes very often come up as crescents.

The osmiophilic platelets of plant cells described by Bowen and others are also probably optical sections of spheres having a duplex structure.

My studies on the spermatogenesis and oogenesis of several forms have convinced me that the Golgi element is essentially granular in form in the spermatogonia and oogonia. With the growth and differentiation of these cells the Golgi elements also grow and very often show, after suitable treatment, a double structure, each having a thick chromophilic cortex, corresponding to the 'externum' of Sembrat ('30) and Hirsch ('39), and a chromophobic core. This latter corresponds to the 'apparatinhalt' of Hirschler, 'archoplasm' of Gatenby, 'idiosome substance' of Bowen and Duesberg, 'idioendosome' of Papanicolaou and Stockard, 'internum' of Sembrat and Hirsch, and the 'vacuome' of Parat.[3] Hirsch ('39), as quoted by Bourne ('42), confirms this, and refers to the Golgi granule as the 'pre-substance' of the Golgi apparatus and to the larger

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[3] See Beams and King ('32) for references.

sphere showing a duplex structure as the 'Golgi system'. This duplex structure of the Golgi sphere has been beautifully brought out by Richardson ('34) in an excellent photograph of an epithelial cell from culture of chick liver.

Discrete Golgi spheres can also be seen with the utmost ease in the living spermatocytes and spermatids of ticks even in ordinary light by the most casual observer (G. P. Sharma,* unpublished). Several years ago Nath and Nangia ('31) reported that the Golgi elements in the young oocytes of the fish *Rita rita* were in the form of granules with a bluish tinge, which could be seen in the fresh material with an ease which was simply astounding.

Reverting to the silver methods, I feel no hesitation in saying that these methods, in spite of the occasionally brilliant results they have yielded, have grievously led us astray with respect to the form of the Golgi apparatus. But what is worse is that these methods (and also the long osmication methods) can blacken mitochondria, nuclear membrane and several other structures in the cell totally unrelated to the Golgi apparatus (see Bowen, '28b for this phenomenon). Indeed it appears that granules of silver and osmium can settle down on many kinds of surfaces. Friend ('36), working on the sperms of British Muridæ, discovered that there was an asymmetrical deeply staining area in the posterior part of the nucleus in all the Muridæ sperms he had seen, which gave the characteristic stain with Feulgen. He named this area as the 'dense posterior region', and he pointed out that in position it agreed with Gatenby's 'post-nuclear body'. G. W. Vaidya, the King Edward Memorial Scholar from Nagpur working at Lahore on the sperm of the squirrel, has confirmed Friend's conclusions. He employed Feulgen's reaction on smears and sections fixed in about seventeen fixatives. The posterior part of the nucleus in each case took up the characteristic stain, showing that the 'post-nuclear body' is only a part of the nucleus. In Da Fano (chilled) preparations no post-nuclear granules were observed in any stage of spermatogenesis, but in Da Fano smears silver was deposited on the posterior part of the nucleus. Gian Chand has arrived at identical results in the sperm of *Cavia*.

Lastly, we must constantly bear in mind that protoplasm is a polyphasic colloidal system in which the suspended particles must tend to assume a spherical form ; and Nath and Bhatia (in press) state that it is incredible that 'long crescent shaped bodies, thicker in the centre and tapering towards each end' (which is the description of the Golgi bodies given by Norminton in *Lumbricus* egg) could be found suspended in the medium of dispersion.

For a detailed review of vital staining of the Golgi apparatus reference may be made to Gatenby ('31), Ludford ('33) and Bourne ('42), but it will be certainly correct to say that, as a rule, the classical Golgi apparatus does not stain with neutral red, which is a basic dye. Nevertheless Hirsch claims (according to Bourne) that the 'pre-substance' of the Golgi system stains with neutral red and I have myself seen the argentophile granules of *Herpetomonas muscarum* staining brilliantly with this dye. In this connection we cannot forget that the protein film round the Golgi body may carry a varying electrical charge as proteins are known to be amphoteric. Nor can we forget that a basic dye, on entering a cell, may become electro-negative or *vice versa*. No reliance can, therefore, be placed on vital dyes, so far as the identification of the Golgi apparatus is concerned.

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CHEMICAL COMPOSITION

The determination of the exact chemical composition of the Golgi apparatus is beset with more serious difficulties than that of the protoplasm in general, as, so far as I am aware, this substance has not been isolated from the cell in anything like a pure state. It should, however, certainly be possible to isolate the microspheres (Golgi elements) from the macrospheres (protein yolk) of the mosquito egg (Nath '29) and determine their exact chemical composition. I recommend this material to the biochemist.

In the meantime we can only guess the chemical composition of the Golgi apparatus from its reactions to the various fixatives and dyes employed in our laboratories. Judging from these reactions there is no doubt that the Golgi bodies are mixtures of fatty substances (fats and lipoids) and proteins. Although fat dyes have been used successfully to stain the Golgi bodies directly in a few cases only (Cowdry '12, Weiner '26, Tanaka '32, Boyle '38, and Tarao '40), the following facts strongly suggest that they contain a high percentage of unsaturated fatty substances.

I have shown in several eggs (see Nath, '33 for references) that the Golgi elements can be demonstrated by treating them directly with 2 per cent osmium tetroxide for short periods, the exact time depending presumably on the degree of unsaturation and the amount of oxidation the Golgi material has already undergone. Bowen ('19 and '28c) succeeded in blackening the Golgi apparatus in the testes of Hemiptera and other insects after 24 hours' immersion in Mann's corrosive osmic mixture. Nath ('32, '37 and '42) in his work on the Decapod sperm often observed that the Golgi apparatus was blackened after fixation in Champy or Flemming-without-acetic. Weigl ('10) found that after 5 to 10 minutes' exposure to 2 per cent osmic acid at 25°C some traces of the Golgi apparatus were just barely visible. After one hour the blackening was more obvious. Foot and Strobell ('01) published excellent photographs of earthworm egg demonstrating the 'osmiophil granules' (which are the Golgi granules according to Gatenby and Nath '26 ; Nath '30 ; and Nath and Bhatia, in press), which had been blackened after a few minutes' osmication even in material previously treated with fixatives containing acetic acid. Ciaccio ('26 and '27) succeeded in staining the Golgi apparatus in the male germ cells of *Discoglossus* with fat dyes after setting free the lipoids from the proteins by using proteolytic enzymes. Tarao ('39), employing Ciaccio's technique, succeeded in staining the Golgi apparatus in the hepatic cells of the mouse and the newt with the fat dye, Nile blue sulphate. Add to all this the fact that the Golgi apparatus is ordinarily washed out by fixatives containing fat solvents.

Nath ('25) reported that in the spermatocytes of *Lithobius forficatus* it was impossible to destroy completely the Golgi material with fixatives containing acetic acid. The same author ('30) made a similar report in the earthworm egg. Nath and Bhatia (in press) have demonstrated spherical Golgi elements (showing no distortion whatsoever) in the centrigured eggs of the earthworm by treating them with Bouin's fluid for ½ to 2½ hours and staining with ·5% hæmatoxylin. Such observations coupled with Ciaccio's and Tarao's experiments (*vide supra*), and 'the fact that the apparatus is sometimes stained with dyes which are used for demonstrating connective tissue fibres' (Bourne, '42) unmistakably prove that the Golgi material contains proteins also.

Bourne ('42) has very ably summed up the position and it will be profitable to quote him: 'We may therefore conclude that the Golgi

apparatus like the mitochondria is composed of protein and lipoidal or fatty substances, or more probably that like the mitochondria it may possess a superficial adsorbed layer of protein. The fact that mitochondria do not react with Nile blue sulphate suggests that they have been completely dissolved by enzymes and that therefore they contain more protein relative to the lipoid in their structure than does the Golgi apparatus. The fact that the apparatus is sometimes stained with dyes which are used for demonstrating the connective tissue fibres supports Tarao's evidence that it contains protein. Experiments with chemical models have shown that fatty droplets in solution containing protein are always surrounded by a layer of adsorbed protein. It is very likely that such a protein layer is present on the surface of both mitochondria and Golgi apparatus, and that this explains why they do not normally react with fat stains'.

Bourne has also given an excellent resumé of the evidence in favour of the view that 'vitamin C is present in the Golgi apparatus of a wide variety of differentiating embryonic cells, and it appears to be concentrated in the Golgi apparatus of cells which are engaged in active synthesis of various substances'. According to the same author, it is very likely that the Golgi apparatus contains enzymes or can synthesize them from the cytoplasm or adsorbs them on to its surface.

FUNCTIONS

Few will deny that the Golgi apparatus is involved in the formation of the acrosome in the maturing spermatid, fat in developing ova and secretory granules in differentiating gland cells. But I have always looked with scepticism on accounts assigning a definite secretory rôle to the Golgi apparatus in the formation of these substances. On the contrary, I firmly believe that the acrosome, fat and secretory granules are alike formed by a direct transformation of the Golgi material.

As early as 1911, Montgomery, working on the Hemipteran *Euschistus*, described the origin of the acrosome directly from a body called the 'sphere' or the 'idiozome', which we now know to be the Golgi apparatus. The account given by Gatenby ('17) for *smerinthus* also unmistakably proved that the acrosome was formed by a direct transformation of the acroblasts (Golgi elements). "When formed the acroblasts are *quite spherical, and their wall is of equal thickness, not more bulging or thicker on one side than the other*" (Italics mine). "Within the acrosomal vesicle there differentiates an acrosomal granule . . . ." "I think the acrosome is finally formed by the running together of several acroblasts". It must be carefully noted that Gatenby described the Golgi element as a sphere and not as a dictyosome, batonette or a crescent, holding the plate-like chromophobe material on its concave side—structures which, as I have already shown, represent optical sections of spheres with a duplex structure. Later in 1920 that doyen of cytology, the late Professor Doncaster, whose epoch-making work was cut short by the cruel hand of death, in collaboration with H. G. Cannon, showed clearly that the acrosome in the louse was formed directly from a rounded body, which was considered to be the Golgi apparatus. This account is based on preparations made with Flemming-without-acetic, and every line of this account bears the imprint of careful observation and interpretation. Daljit Singh, one of my M.Sc. students, has confirmed this account in every detail (unpublished).

Then appeared in quick succession the numerous remarkable publications by the late Professor Bowen on spermatogenesis, glandular secretion

and technique, which literally took us by storm. We required some years to digest and to take stock of the masterly array of facts and the innumerable references to obscure but valuable literature, which the author had taken infinite pains to furnish. The central theme of these publications is that the Golgi apparatus is the centre of synthetic activity *par excellence* and secretes the acrosome and secretory granules without itself becoming transformed into these substances. Bowen ('22 a) interprets the acrosomal vesicles 'as differentiation—rather than direct transformation—products of the Golgi bodies' which are essentially '*plate-like* and not spherical' ('20). The Golgi body is conceived as a crescent (the chromophilic part) partially enclosing the disc-like chromophobic part (Bowen's idiosome). Earlier I have furnished overwhelming evidence to show that such appearances merely represent optical sections of spheres with a duplex structure; and yet Bowen's theory of the secretion of the acrosomal vesicle by the chromophilic crescent in the idiosomatic substance completely breaks down if the Golgi body is a sphere and the chromophilic substance forms a complete envelope round the spherical (and not plate-like) chromophobic substance.

A critical study of Bowen's publications, coupled with my own observations on the Decapod sperm, has convinced me that the acrosome is formed directly from the Golgi apparatus, and is not a secretory product thereof. It is necessary to consider Bowen's papers *seriatum*. In the first place Bowen ('20) is not himself certain of the form of the Golgi apparatus as in the Hemiptera he talks of a 'more or less plate-like or spherical form' in the same sentence (p. 337). In the course of spermateleosis all the Golgi bodies fuse together to form a single large body, the acroblast, which 'is a more or less hemispherical body, pressed close to the nuclear membrane (Fig. 21), the periphery of which impregnates very heavily except for the portion touching the nucleus, where the substance which takes the osmic acid seems to be absent' (p. 339). 'By a process of differentiation connected with the chromophobe material occupying the interior of the acroblast (*Golgi apparatus*), and probably at its expense, there is formed a large, vesicular body containing a small granule, which together form the acrosome of the sperm. The remnant of the Golgi apparatus is cast off and appears to take no further part in the formation of the sperm . . . .' (pp. 351-52).

I find it difficult to accept this interpretation of Bowen for several reasons. Bowen has not figured the necessary intermediate stages showing the fusion of discrete disc-like Golgi bodies to form a single large hemispherical acroblast. If such a fusion did take place, a demonstration of the inevitable intermediate stages would be absolutely essential. Nath ('32), on the other hand, figures all the intermediate stages of the fusion of the Golgi elements which directly form the acrosome in the spermatid of *Paratelphusa spinigera*. Nor has Bowen told us what exactly the 'spermatid remnant' is in the spermatid of the Hemiptera, Coleoptera and Aptera ; nor again what the 'chromatoid body' is in Coleoptera and Aptera—not to talk of the 'juxta-nuclear body' of *Chelymorpha*. Lastly, we cannot ignore the findings of Doncaster and Cannon ('20) and of Gatenby ('17) in the louse and *smerinthus* sperm respectively, notwithstanding the latter's subsequent acceptance of Bowen's interpretations.

If it is not possible to accept Bowen's interpretations in the Hemipteran and Lepidopteran sperms, how can we accept his interpretations in Coleopteran and Apteran sperms where the author is himself doubtful about the whole process of the secretion of the acrosome from the Golgi apparatus? In the Coleoptera 'the development of the acrosome

proper is very difficult to follow, owing to its extremely small size' (Bowen, '24, p. 360). Similarly in the Aptera the 'multiple construction of the acroblast makes it difficult to observe the actual deposition of the acrosome, which is perhaps deposited a little at a time as in the Lepidoptera. In the scanty material at my command, the steps in the deposition of the acrosome could not be followed satisfactorily . . . .' (Bowen, '24, p. 377). Again later in 1926, Bowen, in a paper on glandular secretion, expresses his doubts about the secretory rôle of the Golgi apparatus as 'even in the spermatid it is often impossible to effect a demonstration of the relation between Golgi apparatus and acrosome, particularly when the latter is of the multiple type' (p. 443).

I accepted the interpretations of Bowen (Nath, '26) like all other cytologists including Professor Gatenby, but I find it difficult to accept them today, after my studies of the fate of the Golgi bodies in the spermatogenesis of 34 species of the Decapod Crustacea (Nath, '32, '37, and '42). In all the three Macruran species studied by me the acrosome is conspicuous by its absence, the Golgi material of the spermatid disappearing quickly without forming an acroblast. In the four Anomuran species studied the acrosome is likewise conspicuous by its absence, the Golgi material in *Coenobita* and *Clibanarius* disappearing early in spermateleosis and in *Pagurus* even earlier during the meiotic stages. The nineteen Brachyuran genera studied readily fall into two well-defined groups. In one group represented by *Paratelphusa, Potamon, Ocypoda, Macrophthalmus* and *Matuta*, the sperms are bi-centrosomal and the Golgi elements running together directly form an acrosomal ring which, after fusing completely with the lips of the nuclear cup, cannot be recognised as a separate structure. In the second group, which comprises 14 genera represented by *Leptodius* and its allies, the sperms are tri-centrosomal and the acrosomal ring is never formed, the acroblast (fused Golgi bodies) degenerating completely. Similarly, G. P. Sharma (unpublished) has shown that in the sperm of the millipede *Thyroglutus malayus*, which, like the Decapod sperm, is non-flagellate, the Golgi material completely disappears early in spermateleosis.

It will be futile to urge that the Decapod sperm or the millipede sperm is atypical. On the contrary, it is no more atypical than the sperm of *Cicindela* and *Lepisma* (Bowen), or that of ticks in which the Golgi elements seen in living cells directly fuse together to form the acrosome (G. P. Sharma, unpublished).

Nor can we ignore the findings of Gobind Ram ('37) according to whom the Golgi elements directly form the acrosome in *Rhysida* (a scolopendrid).

Lastly, in view of the findings of Gian Chand (*vide supra*) and Bell ('29), who have demonstrated granular Golgi bodies in the spermatid of *Cavia* and the dog respectively, I feel no hesitation in suggesting that the pro-acrosomic granules of Gatenby and Woodger ('21) are indeed the Golgi elements themselves (and not the secretions of Golgi 'dictyosomes'), which running together directly form the acrosome.

In spite of the recent defections in the Gatenby school (Norminton, '37 and Singh and Boyle, '38) the doctrine of the origin of fat from the Golgi elements in oogenesis is steadily gaining fresh adherents. Indeed the conception has been recently extended even to spermatogenesis and somatic cells. The idea of the origin of fatty yolk from the Golgi elements first originated with Gatenby himself and his collaborators. In *Saccocirrus* (Gatenby, '22) the fatty yolk is 'probably of the Golgi elements'. In *Patella* (Gatenby and Woodger '20, Ludford '21, and

Brambell '24) the Golgi batonette secretes fat in the attached 'archoplasm', without itself metamorphosing into fat ; but it must be carefully noted that even in this egg some of the Golgi rods (according to Ludford) are directly converted into fat. Nevertheless Nath ('24) and Brambell ('24) were the first workers to declare unequivocally that the Golgi elements are directly converted into fat in the eggs of *Lithobius forficatus* and *Helix aspersa* respectively. Later King ('26), working under the supervision of Professor Gatenby, confirmed the direct transformation of the Golgi element into fat in the egg of *Oniscus asellus*. Still later Nath and Nath and his collaborators (see Nath, '33 for references) described the origin of fatty yolk directly from the Golgi elements in a variety of eggs ; and these conclusions were fully confirmed by Gresson ('29, '31, '33 and '33a) and Voinov ('25), and in numerous publications by Professor Bhattacharya and his pupils at Allahabad.[4]

Chemical and physical affinities apart, Nath laid stress on the fundamental morphological similarity between the Golgi element and fat vacuole inasmuch as both were spherical in form. The Golgi elements were conceived as spherical bodies, each having a thick chromophilic cortex and a small chromophobic core. Fat appeared in the chromophobic core which increased in volume with a corresponding attenuation of the Golgi cortex ; and Nath pointed out that the hypothesis of the secretion of fat by the Golgi 'dictyosome' was based (like the hypothesis of the secretion of the acrosome) on an altogether erroneous conception of the morphology of the Golgi body (*vide supra*).

Nath has been insisting that the real structure of the Golgi elements is granular ; and the granule may or may not show a duplex structure, all other appearances—networks, rods, bananas, dictyosomes, batonettes, crescents—being artifacts (*vide supra*). Confirmation of Nath's views is provided by the recent remarkable work of Hirsch ('39), who has described granular Golgi bodies in gland cells, in which complicated networks were previously described by such writers as Nassonov and Bowen. Unfortunately, Hirsch's monograph does not seem to be available in this country on account of the exigencies of war ; but I have been fortunate enough to have had access to a masterly review by Bourne ('42).

According to Bourne, "Hirsch declares that the solid granules of the Golgi substance which show no differentiation into external and internal portions really constitute the 'pre-substance' of the Golgi apparatus. These pre-substances are able to build up nets, but they are the only sort of nets that Hirsch recognises. The other nets, he claims, are due to over-impregnation of separate bodies by excessive amounts of osmium or silver which causes them to link up and simulate a net. These pre-substances may be aggregated near the nucleus or distributed throughout the cell. Each piece of pre-substance gradually develops a double structure with an argentophile and osmiophile cortex ; at this stage it is referred to as a Golgi system. A number of joined Golgi systems are known as polysystems. The outer part or cortex of the Golgi system is known as the externum, the inner part as the internum. Hirsch believes

[4] Nath and Bhatia (in press) have shown that the Sudan IV staining spherules of the earthworm eggs, which arise directly from the granular Golgi elements, do not consist merely of unsaturated fats as they do not stain in the slightest degree with Sudan III, Scharlach R and Nile blue sulphate. They are probably mixtures of fats and lipoids such as cholesterol and phospholipins. These authors consider the Sudan IV staining spherules of the alecithal egg of the earthworm merely as a stage in the formation of neutral fat from the phospholipin of the Golgi elements, a process which is completed in such eggs as those of *Rita, Ophiocephalus, Rana, Emyda, Gallus, Luciola, Periplaneta, Palaemon* and *Paratelphusa*.

that the product* of the cell is formed in the internum . . . ." It is of very great interest to note that the internum which is first small increases in volume to form the product at the expense of the thick externum which, judging from Bourne's text-figure 28 (redrawn after Hirsch), seems to disappear completely, although in the text Bourne does not explicitly mention the complete disappearance of the externum. But Bourne's text figure 27 (redrawn after Hirsch) clearly shows that Hirsch does not know what happens to the externum after the excretion of the product.

Therefore, so far as I can judge from Bourne's summary of Hirsch's work, the origin of the secretory granule in the 'internum' of the Golgi sphere is exactly similar to Nath's account of fat from the Golgi vesicle. Duthie ('34), working on the Harderian gland of the rat; arrived at conclusions very similar to those of Nath and Hirsch. According to this author, the secretory granule arises in a vacuole, which is, to begin with, surrounded by a complete osmiophilic envelope. Later development of the granule 'occurs through a disappearance of the vacuole as in more mature cells, the osmiophilic substance being limited to the crescentic body[5] on one side of the now almost mature granule. It is not clear, however, what finally happens to this osmiophilic cap. *Many mature cells show granules without it, and its later fate is uncertain'* (Italics mine).

At any rate Hirsch and Duthie have proved conclusively that the complicated networks described by Nassonov and Bowen in a variety of gland cells are indeed artifacts. Therefore, the accounts of the latter authors assigning a secretory rôle to the Golgi apparatus, based as they are on a mere topographic relationship between the Golgi 'nets' and the secretory granules, cannot be accepted.

The cytologist, therefore, may well congratulate himself inasmuch as he has unmistakably proved that the acrosome, fat and zymogen all alike arise in the chromophobe material of the Golgi sphere.

Reverting to the origin of fat from the Golgi elements it is of interest to note that the Golgi elements are said to form neutral fats even in spermatogenesis (*e.g.*, Casteel '17, Bell '29, and Gresson '42). Bell's account of the transformation of phospholipin into neutral fat is particularly convincing. Boyle ('38) has shown that even in somatic cells (neurones of *Helix aspersa*) the chromophobe part of the Golgi apparatus is fatty in nature, as it stains with Sudan IV and Nile blue. Ludford ('27) described in tissue culture cells the origin of fat 'in relationship, or by the transformation of, Golgi bodies'. As quoted by Kirkman and Severinghaus ('38), Richardson, Macdougald, and Macdougald and Gatenby, have also described the transformation of the Golgi apparatus into fat in tissue-cultured cells. Lastly, it has been proved conclusively that the Golgi bodies contain a high percentage of unsaturated fats.

Some may urge that if the Golgi bodies are active protoplasmic substances capable of self-perpetuation how can they be transformed into such metaplastic substances as fat and secretory granules? Such an objection will be puerile. For, protoplasm owes its life to the transformation of protoplasmic substances into deutoplasmic ones and *vice versa.* Witness, for example, the transformation of active nucleolar extru-

* The 'product' of the cell is the term used by Hirsch to describe the granules of secretion which are so obvious microscopically in externally secreting glands.

[5] The crescentic body is again the optical section of the really complete osmiophilic cortex of the now enlarged Golgi body.

sions into protein yolk ![6] In other words, life is an expression of a continuous series of changes, both anabolic and katabolic. It may be true that mitochondria (which are also supposed to be active cell constituents) do not form all the metaplastic substances, which they are alleged to form by Meves, Duesberg, etc. (see Cowdry '18), but we cannot ignore the fact that the mitochondria are found in large numbers in all kinds of embryonic cells, and they decrease in number, becoming more resistant to fat solvents, when histogenesis is well advanced. Nor can we forget that mitochondria are directly transformed into protein yolk in some eggs (see Nath '31); and in spermatogenesis likewise they have not been assigned any secretory rôle, merely relegated as they are to the tail region of the sperm. This tail region may not enter the egg in some cases of fertilisation, and even in others where it does normally enter it degenerates completely in the egg.

If the mitochondria of the sperm can be thus dispensed with in fertilisation, the Golgi elements or the acrosome which they form must also be considered non-essential in fertilisation.[7] In the first place it is admitted by the exponents of the secretory hypothesis that the Golgi bodies are sloughed off after they have secreted the acrosome. Secondly all the available evidence about the fate of the acrosome in fertilisation seems to point towards the conclusion that it is a useless, at any rate a non-essential, appendage of the sperm. In *Nereis* (Lillie '12) the acrosome, after breaking into granules in the egg, disappears completely, and in *Ascaris suilla* (Collier '35) it actually forms the cell-wall of the egg. Lastly in the majority of Decapod sperms (Nath '42) and in the millipede *Thyroglutus malayus* the Golgi elements completely disappear without forming an acrosome, and in a few Brachyuran species the acrosome disappears after it has been formed.

Lastly, I may point out the remarkable phenomenon in the red cotton bug (Bhandari and Nath, '30) of the migration of the Golgi elements of the nurse cells along the nutritive roots into the oocyte where they are intermingled with the Golgi elements of the latter. This proves, if indeed any further proof were needed, that the Golgi elements are metaplastic bodies in oogenesis. A somewhat similar transference of the Golgi elements of the follicular epithelium into the oocyte *via* the channels of the zona radiata and fibrillar layer has been described by Professor Bhattacharya and his pupils at Allahabad in a variety of vertebrate eggs. This indeed is a remarkable discovery and emphasizes once more the nutritive rôle of the Golgi bodies in oogenesis.

I think I have said enough to conclude that the present position of the Golgi apparatus (and the mitochondria) is not so chaotic as it looks and that under the seeming chaos there is sufficient order, provided we look at the problem with the eye of both a morphologist and a chemist as urged by Professor James Gray ('31) in those inspiring and prophetic words which adorn the title page of the recent remarkable book edited by Dr. Goeffrey Bourne ('42):

> 'Cytology may rightly claim to be the frontier state in the biological Commonwealth, for within its borders biologists and chemists find common ground'.

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[6] See MacBride and Hewer ('31) for references.

[7] At any rate the boring function of the acrosome in fertilisation (Waldeyer) has been disproved (Bowen '24; Nath '42).

Conclusions

1. The Golgi bodies are not coagulation products, and must not be considered as artifacts. On the contrary, they are very real structures and have been seen (and even photographed) in a large variety of living cells.

2. In undifferentiated cells the Golgi bodies are generally granular in form and have a juxta-nuclear position. With the growth and differentiation of the cell the Golgi granules also grow and get dispersed in the cytoplasm. The Golgi granule, which has completed its growth, very often shows a duplex structure with a thick chromophilic cortex and a chromophobic core. The Golgi bodies are essentially spherical in form. All other forms—networks, dictyosomes, batonettes, rods and crescents—are artifacts, formed by the excessive precipitation of silver or osmium not only on the surface but also in the narrow spaces between the granules. The osmiophilic platelets of plant cells and the curved dictyosome holding the chromophobic 'platelet' in its concavity are optical sections of spheres having a duplex structure.

3. Chemically the Golgi bodies (and the mitochondria) are mixtures of fatty substances (fats and lipoids) linked in some manner with proteins. It is very likely that the outermost layer of the Golgi sphere consists of adsorbed proteins. There is evidence that the Golgi bodies contain less of proteins relatively to the lipoids than the mitochondria. Recently it has been proved that the chromophobic core of the Golgi sphere very often contains vitamin C. It has also been suggested that the Golgi material contains enzymes.

4. The specific gravity of the Golgi bodies is lower than that of the mitochondria and the cytoplasm but higher than that of unsaturated fats, as proved by experiments with the centrifuge.

5. Without a doubt the Golgi bodies are active protoplasmic substances. They certainly possess the power of self-perpetuation, but whether they can arise *de novo* also like the centrosomes nobody can tell. Those who categorically deny the *de novo* origin would give the Golgi bodies a status almost equal to that of the chromosomes—a status which is not warranted by the available evidence.

That the Golgi bodies are active protoplasmic substances is also suggested by their ability to adsorb dyes, metals and organic substances such as vitamin C.

6. The almost universal juxta- or circum-nuclear situation of the Golgi bodies (and the mitochondria) in undifferentiated cells strongly suggests that exchange of material takes place between them and the nucleus. Again the very close association of the Golgi bodies and the mitochondria in such cells lends colour to the claim of Hirsch that the 'pre-substance' of the Golgi bodies is derived from the mitochondria.

7. Never was a hypothesis built on such slender evidence as the secretory hypothesis of the Golgi apparatus. There is not an iota of evidence to suggest that the manufacture of enzymes is particularly a function of the Golgi apparatus. On the contrary, it is very likely that enzymes are formed wherever there is protoplasm.

8. The available evidence points towards the conclusion that the acrosome, fat and zymogen are all formed by a direct transformation of the Golgi bodies, and are not secretory products thereof.

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SECTION OF ANTHROPOLOGY AND ARCHAEOLOGY

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TRUTH IN ANTHROPOLOGY

(*Delivered on Jan. 6, 1944*)

I have taken 'Truth in Anthropology' as my subject, for this seems of great importance at a time when our science has been debased in the interest of false racial theories. Truth is specially important also at a time when a young science is passing the age of puberty and entering maturity. I propose to speak to you very simply as a field-worker. I have no theories to advance and no axe to grind. I am concerned in my own work simply in recording the facts, and in this speech I want to speak to you of some of my experiences in that task and to stress the very great need of a high standard of Truth in all our field-work in order that the science of anthropology may be established in India, both as a means of recording the history of her people and as an instrument which may be of value to Governments in caring for and preserving her aboriginals.

It is necessary to stress this, for anthropology is regarded with some suspicion in India. There are several reasons for this. The attempt of certain scholars and politicians to divide the aboriginal tribes from the Hindu community at the time of the Census created the impression that science could be diverted to political and communal ends. In earlier years the Census authorities tried to distinguish animism and Hinduism. Later the expression, 'Followers of Tribal Religions', was used. The test proposed was to ask a person whether he worshipped Hindu or tribal gods. This test was meaningless. The religion of the aboriginals in Peninsular India at least is obviously of the Hindu family, Hinduism itself having many elements which a theologian would call animistic. In the religious columns, therefore, the aboriginals should have been returned from the beginning as Hindus. Any other classification was worse than useless. It is very difficult even for a trained theologian to decide the exact description of the religion of the various tribes. It is obviously impossible for an illiterate and ignorant enumerator to do so. What we want to know is how many aboriginals there are in India so that we can insist that they have a square deal in the counsels of the country. But now we know accurately neither the religious nor the racial situation, and the unfortunate fact that a number of anthropologists interested themselves in the complicated business of deciding the exact way in which aboriginal should be distinguished from the Hindu religion has done our science harm in public estimation.

But perhaps the chief thing that has disturbed nationalist opinion in India has been the creation of Excluded and Partially Excluded Areas. It is an open secret that this move was largely the work of a distinguished anthropologist at the Round Table Conference. Nationalist India accepted Sections 52 and 92 of the Government of India Act as an insult

to India's political capacity, and at the National Congress held at Faizpur (and again at Haripura) the most sinister motives were ascribed to the British Government. Provincial legislators condemned the arrangement in the strongest terms, and in a debate in the Legislative Assembly in Delhi, Mr. M. S. Aney and Mr. N. M. Joshi condemned all anthropologists as desiring to keep the primitive races of India 'uncivilized' and 'in a state of barbarism' as raw material for their science and 'in order to add to their blessed stock of scientific knowledge'. About this time there arose the curious criticism of anthropologists that they wished to keep the aboriginal tribes in a zoo, a suggestion that can only have been made by people who had never met an anthropologist or visited a zoo. In a zoo an animal is not protected ; it is restrained ; it is taken away from its natural environment and deprived of its liberty. But what the anthropologist desires for his people is the preservation of their liberty, that they may retain control of their natural environment and grow to cultural and civic maturity in freedom, happiness and peace.

As a matter of fact, the Partially Excluded Areas bear no resemblance whatever to the anthropologists' dream. They are very different from the National Parks of North America or the Reserves of Africa. They afford no real protection to the tribesmen, and their establishment has done little except that by irritating public opinion it has drawn attention to the aboriginal problem.

Another reason for the hostility of Nationalist India to anthropology is the belief that books describing the more primitive elements in the population will have a bad effect abroad and will lower Indian prestige in the eyes of foreign observers. It must be admitted that some of the books passing under the name of social anthropology may possibly do this, and I must confess that there is little, for example, in the index to Westermarck's *History of Human Marriage* to console the Nationalist —'temple prostitutes', 'sexual intercourse with priests of Siva', 'defloration of virgins in temples', 'sacrifice of widows', etc.—except perhaps the entry 'Europeans in India, great death-rate among'.

This fear reminds me of the story of the two old English ladies when they first heard of Darwinism, 'Descended from apes, my dear? Let us hope it is not true. But if it is true, let us pray that it may not become too widely known'.

In actual fact, I believe that the apprehension is largely illusory. The people of the world are not so ignorant as we sometimes think. They are perfectly aware that a jungle and a sky-scraper can grow up together. It certainly is not her splendid, virile, honest, kindly aboriginal population that lowers, if anything lowers, India in the eyes of the world. I have frequently talked with American friends on this subject, because I have naturally been worried about it, and their reply invariably has been along these lines. 'We too have an aboriginal population, the Indian tribes, and we can well understand how primitive and highly civilized peoples can exist side by side. We have now learned to admire our aboriginals, and all that we have read about yours leads us to admire them also for their simplicity, their childlikeness and their courage. Indeed it will only increase our respect for India if we learn that Indian politicians are able to solve a problem that we ourselves so badly managed. We interfered in the life of the Indians and almost destroyed them. We trust you won't do the same thing in India'.

In any case, it cannot be too often emphasized that the real business of social anthropology is not the collecting of exciting and curious customs and the recording of bizarre superstitions. It is the attempt to describe

and to make real the entire living beauty of a culture in all its related activities. I do not believe that anyone can read the best productions of the Functional School without gaining a profound respect for whatever tribe has been described. Indeed I would put this as one of the tests of successful writing in this sphere. There are few communities of human beings who, when fully and thoroughly studied and understood, do not excite our admiration and even our love.

As we look back over the history of Indian ethnography and survey the meagre array of books upon its shelf, we can see, I think, why it is that our science does not hold a higher place in the counsels of India. We have been set some very bad examples. The Ethnographic Survey, for all the valable information it collected, was too superficial, too Tylorian, too bureaucratic and too dependent on information provided by untrained subordinates. Unfortunately it has generally been forgotten that the volumes of the Ethnographic Survey were prepared 'primarily as works of reference for the officers of Government' and that, as Crooke said at the time, they were written 'not so much in the interests of anthropological research, as indispensable aids to the work of civil administration'. The result has been the establishment of a tradition of scrappy hurried work largely divorced from personal observation.

Another bad example was set by the reports of the *Census of India*. Here again the impression was all too easily created that social anthropology consisted of a series of notes on interesting and curious subjects. It would be hard to imagine anything less like the productions of the Functional School than the material contained in these reports. Part of it is the obviously inaccurate record of tours in motor-cars. Part does not even enjoy this authority. I notice one writer in the 1931 Census frankly admits that his contribution is the result of 'a hasty perusal of the books available in the District Office'.

Another bad habit set by both the Ethnographic Survey and the Census is the use of subordinate officials as collectors of information. Again and again in Russell and Hiralal's volumes on the Central Provinces we read that a section has been based on information provided by a clerk in the office, by a Tahsildar or by a Range Officer. For his *Grammar of Gondi*, C. C. G. Trench relied very largely on the information provided by his petition-writer—and it is well known that petition-writers are among the most prolific authors of fiction in the whole of India. The climax of this remarkable scientific method was when R. E. Enthoven wrote his *Bombay Folk-Lore* as a result of questionnaires issued to Primary Schoolmasters.

I do not like to arraign those fascinating little Journals called *North-Indian Notes and Queries*, for they are a continual delight to me and I have a profound admiration for the memory of William Crooke. But these too helped to create the idea that anthropology was something like stamp-collecting or assembling material in a shop window. Scores of tit-bits were arranged: many of them made excellent after-dinner stories. But this bore no resemblance to the science of anthropology as we know it today.

I think another unhappy result of the earlier method was the habit, which has almost become a convention in India, of writing, one after another, endless monographs on individual tribes. This is really little more than the old Ethnographic Survey on a much bigger scale. In each of these monographs (and this is specially true of the Assam monographs) the same subjects are treated again and again. The same points must be made over and over for the simple reason that in India all the tribes

share to a great degree a common life and culture. There are no doubt certain broad divisions. But if we take Peninsular India, the tribes of the centre and the east form a block of humanity which lives everywhere under almost similar economic conditions, with ideas on marriage that vary little from place to place, with a religion that is substantially the same. There are differences, of course, and it is remarkable how, in spite of great similarities, it is still possible after some experience to recognize one tribesman from another and to distinguish certain points of his culture. But some new technique needs to be devised to save us from the constant repetition of facts in individual monographs.

The lack of reality in our Indian ethnographic library is, I think, the reason why the Indian evidence is so frequently neglected in general works of anthropology. In Boas' *General Anthropology* (New York, 1938), there are only the most meagre references to India. The Index gives 'cultivation of rice, folktales, mathematics, paleolithic culture, polyandry and throwing sticks'—which, to say the least, gives a very curious picture of our sub-continent. J. D. Unwin, in his *Sex and Culture* (Oxford, 1934), one of the few books which discusses the value of its authorities before proceeding to quote from them, declares that although he studied the Veddas, Todas, Oraons and 'other famous peoples of India and Ceylon', he did not feel able 'to place the requisite value upon our knowledge of them' and hence omitted all references to them in his discussions. On the other hand, he found no fewer than twenty-eight American Indian societies which had been studied in a sufficiently scientific manner for his purpose.

Even this neglect, however, is better than the indiscriminate and uncritical quotation to which India has been subjected by writers like Frazer, Westermarck and Briffault in support of their various hypotheses. These writers seem to quote anything and everything so long as it is in print. With glorious indifference they reproduce the opinions of scientists, officials, politicians (so long as they are on the Imperial side), missionaries, tea-planters, chance travellers and chaprasis. The only standard of judgment appears to be political respectability and the fact of being in print. I remember that once when that great scholar-missionary, Edwin Smith, was staying with me in Mandla, I apologized to him for a number of scraps of newspaper that were littering the compound. 'It is a curious thing', I said, 'that whenever an aboriginal cleans a place, he carefully avoids tidying up any bits of paper. He cannot believe printed matter to be rubbish'. To which Edwin Smith replied, 'What optimists your aboriginals are!' I think we may ascribe a similar spirit of optimism to some European writers in their references to India, for they cannot believe any printed matter to be rubbish.

A particularly bad example has recently occurred in an important and almost standard work, *Modern India and the West* (Oxford, 1941). Mr. O'Malley, a scholar of distinction, whose recent death we must all deplore, gives a description of the Juangs which is based on Vivian Meik's *The People of the Leaves*. O'Malley quotes this 'first-hand account' as showing that in the State of Rairakhol the Juangs are at 'the nadir of primitivism', still only wearing leaves, unable to count above five and in their sexual relations observing no table of kindred or affinity, but living like animals. *The People of the Leaves* is a spurious work which was exposed by Sarat Chandra Roy in the pages of *Man* years ago. There are no Juangs in the State of Rairakhol, and there is evidence that the author never visited the villages he describes and his photographs are not of Juangs but of Bhuiyas dressed for a certain festival. Meik's account

of the Juangs is false in fact as well as in sentiment. The Juangs are actually particularly strict in their sexual relations and their regard for the table of affinity. Yet here is a responsible writer in an important work using as his authority a book which a moment's enquiry should have shown him to be utterly untrustworthy.

Another misuse of our authorities, which in this case is due more to the authorities than to those who use them, is a habit which mars the otherwise admirable and stimulating monograph of O. R. Ehrenfels, *Mother-Right in India* (Hyderabad, 1941). Here the author gives lists of tribes which have such institutions, as for example, of the serving marriage, sexual liberty, matrilocality, etc., and bases his lists on information collected from the volumes of the Ethnographic Survey. The result is apt to be misleading. For example, almost every tribe and caste mentioned in Russell and Hiralal's book on the Central Provinces has the institution of the serving marriage, but the authors do not trouble to mention this fact in more than a few cases. To make a list, therefore, of the tribes for whom this institution has been specifically mentioned is to give the impression that these are the only people that have it, and this is incorrect. It is also hard to see how anyone could base his ideas of sexual liberty among the aboriginals on the works of Russell, Thurston or Risley.

Truth in anthropology demands a scrupulous adherence to the highest rules and standards of field-work. First and foremost I would put the length of time that an investigator should spend among his people. Some years ago I heard Westermarck deliver the Huxley Memorial Lecture, and I will always remember his describing how forty years before, when he was preparing his book *The Origin and Development of the Moral Ideas*, he thought it might be useful for him to acquire first-hand knowledge of some forms of culture differing from his own. 'I intended', he said, 'to go to the East to study both civilized and savage races, but sailed first for Morocco. And I never went farther. I soon realized what a laborious undertaking it is to acquaint oneself sufficiently well with the people even of a single country. Morocco offered the advantages of being little explored as a field for anthropological studies, absolutely untouched by modern civilization, and within easy reach of Europe. I went there time after time, preparing my trilogy on the customs and ideas of the Moors, which was based on my experience among them during nine years in the course of more than three decades'. But here in India, particularly where anthropological work has been mainly the hobby of persons otherwise busily engaged, how short has been the time given by many investigators to their task! Ruben wrote his massive work on the Asurs after a stay among the tribe of less than a month. Indian writers, whom I will not name, have produced articles and monographs after a week or a fortnight's stay in tribal villages. My own book on the Baiga was published seven years after I had settled down in the Baiga country, yet I am still today discovering new facts about the tribe and points where I should like to modify my early conclusions.

Westermarck, in the lecture to which I have already referred, was (I am glad to say) emphatic that the proper training of field-anthropologists was a matter of first-rate importance, but he disagreed with Radcliffe-Brown's statement that we can no more rely on information given by untrained observers in social anthropology than we can rely on the observations of an untrained person in such sciences as geology, physics, or chemistry. 'If this was the case', says Westermarck, 'we should scarcely have any comparative anthropology at all, for the number

of properly trained ethnographers has hitherto been exceedingly small'. Indeed in India they could be counted on the fingers of one hand. Indian ethnography has suffered undoubtedly from the absence of trained observers, but it has gained from the work of people who have spent their whole lives in the country they describe.

Westermarck very rightly stresses linguistic qualifications. 'A knowledge of the language', he says, 'is in my opinion an indispensable qualification for which no sociological training can serve as compensation. To be able to converse freely with the people without the aid of an interpreter should be the field-anthropologist's most serious aspiration'.

Another quality that makes for success is a simple habit of life and a sympathetic temperament. The field-anthropologist must get right among the people. It is essential that he should travel light. It has been recalled that the late Maharaja of Bikaner used to travel through famine areas in his State accompanied by but a single servant. You cannot observe mankind from the howdah of an elephant or the seat of a motor-car. I once went on tour in a State that was, I think, a little nervous about what I might discover, but did not like to say so. In order to ensure, therefore, that my investigations should bear the least possible fruit the authorities smothered me with kindness. I was provided with no fewer than eighteen chaprasis. I was given elephants, tents and furniture in abundance, a large double bed, a dressing-table, clothes-racks and two commodes. The natural result was that the hundreds of unfortunate villagers, who were impounded to move my goods from camp to camp, were so exasperated at the work they had to do, and so bothered by the number of visitors they had to support that I practically got no information at all. The anthropologist should aim at being what Chesterton in one of his excellent detective stories called 'a mentally invisible person', someone who will fit as far as possible into the picture. It is very difficult for a foreigner to do this except after long residence in an area. But Indian enquirers should be able to adapt themselves and achieve it without difficulty.

But, although the investigator must on one side be the perfection of sympathy, on another he must be suspicious. In his enquiries he has to be both detective and magistrate, for, particularly in India, even the friendliest tribes throw up a barrier of concealment to hide their most cherished ideas and customs from the prying eyes of the stranger. The investigator has to follow every little clue if he would track down the information that is sometimes as elusive as the solution of a baffling crime.

Sometimes the people are afraid of giving information. This particularly applies when you are investigating anything that approaches the realm of what is called criminal or forbidden. There is the very natural feeling that the visitor may possibly be a policeman in disguise. The fear, moreover, is not only of possible inconvenience or punishment, but many tribes believe that it is literally dangerous to give information to outsiders. After W. V. Grigson, the most sympathetic of observers, had finished his enquiries in Maria villages, the people attributed every subsequent depredation of tigers to the information they gave him. I myself was at one time believed to have made all the women of an area barren. Some tribesmen have ceremonies to purify their villages after the Census operations have defiled them.

Such timid informers are, however, less dangerous than the self-righteous and pious. These are the people who will say 'No' to everything which they think might lower the reputation of their tribe in foreign eyes. Throughout Bastar State, for example, the village headmen

everywhere deny that they eat beef. Yet beef-eating is universal. But the tribesmen imagine that to admit it may bring upon themselves the scorn of neighbouring Hindus. The institution of the village dormitory is constantly denied by tribes where its authority is beginning to decay and where the people's belief in it has been shattered by external criticism. Raymond Firth has an interesting account of a witness of this type. He describes how he followed through the Eastern Solomon Islands in the footsteps of Rivers. 'And while I admired the industry with which he had amassed so much of his data from brief calls at villages and sessions with natives on the deck of the vessel, I became increasingly convinced of the arid quality of this material, its superficiality and lack of perspective. This impression was confirmed by my stay in Tikopia. Rivers himself was there for only a single day and nearly the whole of his account, as he himself stresses, was derived from John Maresere, a native of Uvea who had lived for twenty years on the island. To this man's information Rivers attached an exaggerated value. Forgetful of the lessons of his own field-work among the Todas, which demonstrated the prime importance of lengthy personal contact with the people, he was content to reproduce the material of a single informant, a foreigner, collected in a lingua franca, without the possibility of check by direct observation. Hence the account is inaccurate in a great many details of custom and language, even in such simple matters as behaviour towards chiefs, and the picture of Tikopia life is over-simplified and distorted.

'His presence on the deck of a Mission vessel may have accounted for Maresere's denial of the existence of polygyny, of which there were a number of cases, many more than now, while his own personal situation may have led him to state that adultery was rare. "In particular", said Rivers, "John was most emphatic in his statements that a married man would never offend with an unmarried woman". One can perhaps understand the vigour of this when it is realized that it was precisely for this offence, committed with the sister of his "father" and protector, the Ariki Tafua, that he had been banished from Tikopia'.

The exact opposite of this type of informant is the professional savage who has been investigated before and has been rewarded. He generally wants to say too much and, although he seldom has the wit to invent customs that would be of interest to the ethnographer, he may give a distorted picture of his people by over-emphasizing those things that he thinks will appeal. I myself fell into a trap of this type when preparing my book on the Baiga. In a neighbouring village there lived a very famous old Baiga called Jogi Dewar. This ancient, who had a vivid recollection of the Mutiny, had made a collection of old solar topis that had been presented to him by Conservators of Forests over a period of fifty years. Shortly before his death, he celebrated his marriage with his own grand-daughter. I was at that time interested in such relationships and, although Jogi was a familiar visitor at my house, I went to see him and got his story. He gave me his genealogy and showed that the girl was his 'real grand-daughter', that is to say, the daughter of his own daughter. With great amusement he introduced to me his son-in-law who was, of course, at the same time his father-in-law. I wrote at the time that 'I do not know how much of his life-story is true, but it is very interesting'. But everything about the incident seemed perfectly straightforward and I recorded it. Then Jogi died and a year or so afterwards his son came to see me, and on account of a lingering doubt in my mind I began to discuss with him the old man's last marriage. And now the

son declared that the girl Jogi had married was not the daughter of his own daughter, but the daughter of his own brother's daughter. Of course, in Baiga eyes this relationship is precisely the same. But when I asked why Jogi had so carefully deceived me in the matter, the son laughed and said that in fact he had done so for the publicity. He had thought that people would be more interested in him if they thought he had married a girl in that particular relationship. Actually the son told me the situation was even more curious than Jogi had originally revealed. The girl had married two husbands at the same time ; one of them was Jogi and the other a young boy who was Jogi's own grand-son. The boy went round the pole with the girl four times and Jogi for the remaining three, and so the girl married at the same moment 'grand-father' and 'grand-son'. But in fact I believe the whole thing was in this particular case little more than a publicity stunt.

In our investigations we should always suspect a negative. A. N. Mitchell once told me that when he was compiling his *Gondi Grammar* his experience was that at first he would put down that a certain linguistic form was unknown, for everyone would deny it. In a month or so he would cross out the word 'unknown' and put 'rare'. In six months he might find himself changing 'rare' to 'occasional', and in more than one instance the final word was 'common'. If this is true of comparatively innocuous matters like the use of verbs and adjectives, how much more it is likely to be the case when we are dealing with such subjects as religion, sex or death!

One of the most important needs of social anthropology is that it should be firmly based on statistics. By no other means can we eradicate from our literature the baneful presence of the general statement. This is particularly necessary in questions of sex and marriage, about which writers in India have a passion for being discreetly vague. Thus Unwin laughs at such statements as that 'The girls are modest and beautiful, the majority chaste'. A distinguished writer once committed himself to the opinion that no girl of a certain tribe ever came to her marriage as a virgin. By what possible means could this remarkable piece of information have been achieved, except by direct revelation from Above? Westermarck writes about polygyny in Central India and bases his views (which are very controversial views) on the opinions of Forsyth and Hislop, an article in the *Calcutta Review* and the childish *Wild Tribes of India* by Rowney. But how could these authorities possibly have had any real knowledge of the prevalence or otherwise of polygyny in the backwards of Central India at that date? They could have had nothing more than the most general idea. The value of statistics in the discussion of such a question as this is well shown in a story from the eighteenth century. A gentleman was talking to Samuel Johnson about France and told the great lexicographer that in that country as soon as a man of fashion married, he took an opera girl as his mistress, declaring this to be the general custom. 'Pray sir', said Johnson, 'How many opera girls may there be?' The gentleman answered, 'About four score'. 'Well then, sir', replied Johnson, 'You see there can be no more than four score men of fashion who can do this'.

In attempting to reach the realities of tribal life, I believe that tribal poetry is of the first importance. There is a remarkable passage in Leigh Hunt which describes how poetry leads us on from dry fact to living reality.

'Poetry begins where matter of fact or of science ceases to be merely such, and to exhibit a further truth ; that is to say, the connexion it has

with the world of emotion, and its power to produce imaginative pleasure. Inquiring of a gardener, for instance, what flower it is we see yonder, he answers, "A lily". This is matter of fact. The botanist pronounces it to be of the order of "Hexandria Monogynia". This is matter of science. It is the "lady" of the garden, says Spenser; and here we begin to have a poetical sense of its fairness and grace. It is

"The plant and flower of light",

says Ben Jonson; and poetry then shows us the beauty of the flower in all its mystery and splendour'.

The evidence of folk-song, story, proverb and riddle is the authorization of our other material, for here are actual documents which can hardly be forged. Here we have the traditional tribal approach to every problem recorded by the people themselves long before we asked our questions or disturbed them by our presence. For too long a time anthropology has regarded these songs as linguistic specimens. It has relegated them to appendixes. It has been remarkably slow in weaving them into the main texture of tribal life and thought. Westermarck, in the lecture to which I have already referred, urges the collection of proverbs, both as a linguistic exercise and for the light they throw on social institutions. The work done by W. G. Archer on the folk-songs of Bihar is a significant step forward in modern ethnographic studies.

A science must take the help of science in proclaiming its findings to the world. There is no more excuse today for an anthropologist to publish his work in a badly printed, badly illustrated form than there is for a doctor to do an operation with rusty and broken instruments. The purpose of an author is to be read, and I believe that at least one reason why so little attention is paid to Indian ethnographical work is that it has appeared in such a faulty and imperfect form. The distinguished work of Sarat Chandra Roy, for example, suffers greatly from the imperfect printing of his text and quite shocking reproduction of his illustrations. In his case there was a reason for this, a reason which is so characteristic of his goodness and charity that one can forgive him. He believed that it was his duty to give the work of producing books about aboriginals to the aboriginals themselves and, therefore, entrusted their publication to a little printing press run by Mundas in Ranchi. But other writers have not this excuse.

Few people in this country appear (if I may judge from the manuscripts received for publication in *Man in India*) to have any notion of how to prepare matter for the press. In a recent article of 12 pages which I was sent, I found no fewer than 141 mistakes. Some of these mistakes are cleared up in proof, but far too many inconsistencies carry through on to the printed page. The time to read a proof is before your manuscript is set up in print. Science has brought the art of photography to a very high degree of perfection everywhere—except in anthropological publications. There is no real excuse for producing pictures which are badly centred, which are full of irrelevant background (as when Roy gives us a photo of an Uraon in full war-dress against the background of the Anglican Cathedral at Ranchi). Expert advice is available and should always be consulted.

The technical problem of how to deal with words in the Indian languages is very great. Here again the scientist must remember that the purpose of an author is to be read. If his book is full of unfamiliar words, especially if these are printed in italics and with accents and worst of all with diacritical marks (those 'damned dots', as a celebrated politician once called decimal points), he has no hope of a world public. I think

we ought to have a convention about the spelling of Indian words and their accentuation, about how many and which should be printed in italics, and whether or not the damned dots should be included. My own opinion, and I believe it to be the view of at least one of our great University Presses, is that we should aim at a simplification of all these things. In the first place, as few Indian words as possible should be given in the text. I strongly recommend the adding to every monograph of social anthropology a classified glossary on the lines of Grierson's *Bihar Peasant Life*. In this way all relevant words will be given in a place where the linguist can find them most easily, and they will not disturb the eye and distract the attention of the reader who seeks other kinds of information.

In the glossary the spelling of words should be as phonetically correct as possible, but in the text I think we should aim at simplification. The English language is not a phonetic one. It does not allow for accents. It certainly does not permit the use of squiggles above the line or dots below it. Take, for example, the printing of Latin words in English books. The proper pronunciation of Latin words is a matter of the utmost concern to the ordinary Englishman who seldom nowadays knows how to achieve it. Yet publishers never permit the placing of any accent upon Latin words. Least of all should this be done when words are printed in Roman type and not in italics. It is both pedantic and inconsistent, for example, to put accents on the names of places which themselves have already been anglicized. The height of inconsistency is found where an accent is put on a word like Maratha and the word is then given a wholly illegitimate English plural.

Henry James sets as the ideal of a writer of fiction, 'to put all that is possible of one's idea into a form and compass that will contain and express it only by delicate adjustments and an exquisite chemistry, so that there will at the end be neither a drop of one's liquor left nor a hair's breadth of the rim of one's glass to spare'. That is an ideal for the artist, yet it is noteworthy that it is put in a simile drawn from science. The anthropologist, who has to deal with poetry and those manners and emotions which in other hands provide material for the novel, as well as with topics more technically 'scientific', has a special duty to make his work artistically perfect as well as scientifically correct. Art and poetry are the sisters of science in the great family of Truth.

All these things, you will say, are simple enough ; some of you may even consider that they are elementary. Yet I believe that the neglect of these principles has done harm to our cause in India, and I felt it was my duty to draw the attention of my fellow-students to the need of their observance.

For anthropology must be established in its rightful place in India ; it is urgently needed for the life and safety of the tribesmen. A whole world of Indian life and culture is rapidly passing away without proper record, because we are not doing our field-work properly. The collections in our Museums and the teaching in our Universities are equally inadequate to the task that lies ahead. A very great change must be introduced, and I believe myself that that change will only come as we establish ourselves more and more firmly in the idea of Truth.

Mahatma Gandhi has set us all thinking again in terms of Truth. Above the changing flux of earthly existence there rises the Eternal Truth, in that Yonder which is the true home of man. And since man was made for Truth, he is restless until his feet are on the highroad which will lead him to his home. For the Truth of science is no static thing ;

for his whole life man must pass from truth to truth. 'All Truth is a shadow except the last—except the utmost, yet every Truth is true in its kind'. The scholar's life becomes a daily parting with shadows—and some of these will have become dear to him. Yet he knows that of all the adventures of which the world is full, there is not one that can compare with his. For other ambitions and desires seek partial and imperfect ends: he alone has set out for the Whole. 'It is for this', says Plotinus, 'that souls must run their ultimate and greatest race: the prize of all their striving is this, that they be not without portion in the supreme spectacle. Blessed is he whose eyes have seen the blessed vision: but he that fails in this has verily failed. For a man may fail to win fair bodies, may fail to win power or office or a king's throne and yet it is not failure; failure it is, although he should gain all else, if a man fail of This—for whose winning he ought to reject thrones and principalities of all the earth and sea and sky, if by leaving these behind him and looking beyond them his vision might be converted Thither and he should see'.

And the scholar's quest is one that cannot fail. Truth is the one thing that cannot be sought in vain. He may not find the truth he expects, or even the truth he wants, but he will one day, if he has been loyal to the spirit that drives him onward, see the veils of ignorance and delusion torn away and the shadows of partial understanding banished by the pure radiance of the Eternal Truth in its beauty. Then the scholar will himself be transformed into Truth, and one with Truth that is eternal, he will find his immortality, perhaps the only immortality there is.

SECTION OF MEDICAL AND VETERINARY SCIENCES

President :—DR. K. V. KRISHNAN, M.B.B.S., M.R.C.P., D.B., D.Sc., F.N.I.

MEDICAL EDUCATION

(Delivered on Jan. 5, 1944)

CHOICE OF SUBJECT

I have chosen the subject of medical education because, firstly, the subject is of importance not only to medical men but also to the government and the general public. For, on the standard of medical education reached in any country largely depends the soundness of the medical men, the efficiency of medical service provided by government and its usefulness to the community. Secondly, when I was appointed professor in a postgraduate teaching institution in 1934 my active interest in medical education started. The close contact with students from the different medical colleges and schools in India was an eye-opener to me as to the true standard of undergraduate medical education in the country and it impressed upon me the need for improvement in certain directions. A study of the position of postgraduate medical education in which my special interest lay likewise revealed that the facilities provided so far are utterly inadequate to meet the growing needs of the country. Although several prominent medical men had formed a similar opinion and had given expression to that view, no one had formulated a constructive programme for adoption. Thirdly, within the last decade several books have been written and many articles have appeared in foreign medical journals on "State medicine", "Social medicine", "Medicine and human welfare" and other allied subjects. These clearly indicate the trends of thought in western countries and the lines on which medical education of the future is likely to develop. A study of these has created an unrest in the minds of medical educationists in this country as elsewhere. While some conservative members among the educationists still remain convinced of the excellence of existing systems and institutions, the progressive elements, conscious of the benefits that are likely to accrue to the profession and to the public from the adoption of the newer schemes, feel that the existing educational institutions should be suitably reorganised so that they may produce "physicians of to-morrow" rather than "physicians of yesterday" as at present. Lastly, despite the atmosphere of war, the growing financial stringency all around and the uncertainties of the future, people are thinking of post-war reconstruction. They are discussing freely programmes of all kinds in almost every field of human activity. It is not unreasonable therefore for the Indian medical profession to discuss medical education which is the pivot on which the future of the profession rotates. Furthermore it is now over one hundred years since the first medical college was established in India and it is time we, medical men, took stock of the

achievements of other countries as well as our own in the educational sphere, expressed our hopes and aspirations for the future, prepared appropriate schemes for improving our system and got them executed as quickly as possible, after the war is won. These then are some of the reasons for my choice of the subject and I shall now take up the subject proper for detailed consideration.

Dual Standards

In India we have a dual standard of medical education. There are medical schools turning out licentiates who are men of a lower standard and medical colleges producing university graduates who are men of a higher standard. The lower standard of medical qualification had to be instituted in India as in many other countries chiefly for economic reasons and as an interim expediency in the evolution of medical education. Now, with the exception of India and Russia, there is no other country in the world which retains this dual standard. Russia is fast trying to abolish the lower standard and develop the higher and she has gone a good way in achieving this object. India too has unanimously resolved that the lower standard of education should be abolished. Provinces like Madras and U. P. have already given effect to this resolution and the other provinces, but for the war, would have followed their good example by now. Nevertheless, we may hope that in the very near future India will be having only medical colleges and no schools. Therefore I shall consider here mainly the position of medical education in our colleges making passing reference to the position in the schools wherever necessary.

Adequacy

In considering the needs of medical education of a country, almost the first question that arises is, "Are there a sufficient number of medical institutions producing the requisite number of medical men?" The standard aimed at in western countries is to have enough medical colleges so that, there will at least be one qualified doctor for every 1,000 of the population. Britain with a population of 50 millions has 55 institutions and 61,420 doctors; U. S. A. with a population of 130 millions has 77 institutions and 150,000 doctors; Russia with a population of 180 millions has 72 institutions and 120,000 doctors; India with a population of 388 millions has 37 institutions and 42,000 doctors. According to the western standards mentioned above, India should have at least 400,000 doctors or ten times the present number. The ten medical colleges and 27 medical schools in existence in India are jointly producing every year about 1,700 new doctors. At this rate it is easy to calculate how many years India will take to produce the requisite number of doctors. Unless some practicable plan is put forward to hasten production (without lowering the standard and without considerable extra cost) there seems to be no hope of solving this question of inadequacy of doctors in the near future.

It may be argued that even if the requisite number of doctors are made available it may be difficult to induce them to settle down in rural areas where they are most needed and to face continuously the various hardships prevalent in these areas. My answer to that is, that the difficulty is not an insurmountable one, provided a comprehensive scheme of selection, training and employment of rural medical officers can be

adopted. I propose to present at a later stage such a scheme for your consideration.

Stage

If we trace the evolution of medical education from the ancient times to the present day we find that it has passed through at least six distinct stages of development. In the first stage, disease was believed to be caused by the anger of gods and it had to be fought by spiritual means and by the appeasement of the irate gods. Medical education meant the production of the "priest doctor". In the second stage, some knowledge of the uses of herbs and medicines in the treatment of disease had been acquired. This knowledge was possessed by a few men only and they, cloaked in empiricism and personal prejudices secretly imparted the knowledge to their apprentices and assistants. Medical education then meant the production of the "quack doctor". In the third stage, systematic knowledge based on experiment, observation and inference had accumulated. There was no secrecy about this knowledge. Training in medicine began to be given to suitable pupils by groups of qualified men competent to undertake the responsibility. Medical institutions sprang up and these gave courses and issued diplomas. Medical education meant the production of the "tradesman doctor" or in other words the doctor who sold his knowledge for money to his clients. In the fourth stage with the development of the scientific outlook, universities stepped into the picture and organised medical education on sounder lines, advocating the advancement of knowledge for its own sake and placing higher ideals in front of the medical men. Universities provided ample opportunities for specialisation in the various branches of medicine and encouraged research. Medical education meant the production of the "professional doctor" with a scientific outlook who practised medicine not only as a vocation but also as an art. In the fifth stage, with the increase in knowledge of the causation and prevention of disease and consequent recognition that medicine had not only a curative side but also a preventive side, the practice of preventive medicine began to be recognised as an additional responsibility of every medical practitioner. Medical education stressed the importance of preventive medicine and it produced the "preventive doctor" with the dual responsibility of preventing and curing disease. In the sixth stage, which is just being reached, medical education is taking one more step forward and training men not only in the principles of prevention and cure of disease but also in the methods of maintaining health of individuals and communities. In other words, stress is being laid on the importance of solving problems pertaining to "positive health" in addition to those relating to "negative health". Medical education has now come to mean the production of the "health doctor" with one more responsibility added to the existing list, namely, the responsibility of helping people to build up positive health. Judged on the basis of the above classification we find that different countries have reached different levels. For example Russia, in which the State and the people are one, is already in the sixth stage, while Britain and U. S. A., which are democratic countries, are in the fifth stage and nearing the sixth. India, which is a dependent country, is mostly between the third and fourth stages and just touching the fringe of the fifth stage. Despite the fact that all the medical colleges in India are affiliated to Universities, education in them is not planned according to the true principles of university education as enunciated by Abraham Flexner nor does it stress sufficiently forcefully the preventive outlook or

the positive aspect of health. The outlook of most, if not all, medical colleges is still to produce the "tradesman doctor" who can prescribe a bottle of medicine or use a surgical instrument for the cure of disease. Although I fully realise that the stage of evolution reached by any country largely depends upon the political, social and economic status of that country I am also convinced that a good deal depends upon the initiative and enthusiasm of the medical profession and upon the generous public support that it is able to command. If Indian medical colleges are found lagging behind, the responsibility for that cannot be placed entirely on government; the profession and the public must share and share equally that responsibility. A study of the rapid progress that is being made in U. S. A. in medical education shows how much the country owes to the energetic efforts of the American Medical Association, to the philanthropic support of an enlightened public and to the wise lead of certain progressive universities.

Objectives

The objectives aimed at by a medical college generally give an idea as to the quality of education it imparts. Colleges of higher rank have invariably in view approved objectives and suitable programmes for attaining them. In choosing their objectives the colleges take into consideration mainly three needs—the needs of the country, the needs of the profession and the needs of science. The recognition of the importance of the first helps to plan suitable programmes for producing the right type or types of medical men who will best serve the people, the second helps to provide suitable facilities for maintaining a high standard in the profession and the third helps to formulate suitable research programmes for the advancement of science. Unless these three objectives are kept in view by a teaching institution it cannot be considered to have attained a high rank. Judged by these standards most Indian medical colleges can be said to have objectives that need revision.

India is predominantly a rural country. 95 per cent of her vast population live in rural areas. The majority of these receive little or no medical aid. Although there are over 42,000 qualified doctors in the country, they are mostly distributed in urban areas. The majority of the doctors produced in our colleges are averse to settling down in rural areas for one reason or another. The few that do are unable to cater to the special requirements of the rural people and to adapt themselves to the conditions of the villages for long. This unfortunate situation is due to a number of factors one of which is that our colleges do not produce the right type of rural medical practitioners. Only if and when they produce this special type they would be considered as having catered to the country's needs. What is needed is a band of doctors with true missionary zeal, with genuine rural bias, with proper understanding of the diverse rural problems, medical and non-medical, and with high humanitarian ideals, who will be content to devote their lives and knowledge at least for a set period to the service of the people for a small reward. The country needs and demands such a band of selfless workers and it is not difficult to constitute that band if one goes about in the right way. It is the duty of our medical colleges to select the right type of men, train them suitably and make them available to the rural people who badly need them. It can be done even under the present economic conditions and available resources and I shall present my scheme for that later.

While no one can deny that the majority of graduates from our medical colleges compare well with those of other universities, the same is not true of the products of our medical schools. And because the bulk of the medical profession in India today is composed of the latter, the average standard of the medical profession could not be regarded as high as it should be. The situation would have been much better had our educational institutions realised earlier that medicine is a progressive science, that new knowledge is being added very rapidly and that if a physician is to keep abreast of all recent advances, opportunities for continued study in the fields in which he is interested must be made available to him at regular and frequent intervals throughout his professional career and that this is one of their primary responsibilities. Our medical institutions have all along known that the education of the majority of our medical men practically ended with graduation. They have also known that it is largely left to the initiative of the individual doctor to train himself in the best way he could after graduation. And yet they failed to organise proper postgraduate courses for our men, particularly for the general practitioner. Where our educational institutions failed, there it was the duty of our medical associations to have stepped in ; but these too have not given the lead in the matter so far. Unless it is realised that the general practitioner represents the bulk of the profession and constitutes its real backbone and unless well organised programmes of postgraduate education are offered to him as well as to those interested in other branches of medicine periodically, we can never hope to raise the standard of the profession to the level reached by other countries. This being one of the vital needs of the profession I shall discuss it again.

Advancement of science can only be achieved through men with a scientific bent of mind. It is the responsibility of the medical colleges to produce such men through inclusion of research programmes in education. The function of education is not only to impart available knowledge to the students but also to point out to them the gaps in our knowledge and the method of filling up these. Through training in research alone can we hope to sharpen the appreciation of the scientific methods, and to enhance the ability to apply scientific facts logically to the problems that are waiting to be solved. The power to discriminate and to judge and the desire to add to existing knowledge are best developed only through stimulation of the research spirit. It is for these reasons that true university education includes research in its scope.

In India, most medical colleges have only limited resources for prosecuting research. In quantity and quality their research activities need to be much augmented. Even where the staff are engaged in research it is not usual for the students to participate in the work. It is time that our colleges realised the importance of research in their educational programmes and made it compulsory for the staff to undertake the solution of problems of national importance and encouraged the students to tackle at least a few minor ones during their collegiate career. The promotion of research being one of the recognised functions of every university, the Indian universities should offer munificent grants to medical colleges for the purpose and guide their research activities as they do at present in other branches of science.

Library

The library is a vital part of a medical college. It reflects in a way the scientific attitude of the college and the standard of education it

imparts. A well selected collection of books, monographs and periodicals covering as completely as possible the entire field of medicine is a necessity both for the student and the staff. Since the recognition of the inter-relationship between medicine and the other sciences such as chemistry, physics, biology, psychology, anthropology, economics, agriculture, sociology, etc., the progressive institutions keep a certain number of references in these sciences as well. The modern tendency is to spend a good portion of the money available on current journals and monographs rather than on text books which rapidly go out of date and which chiefly review that which has already appeared in periodicals. It is also being felt that the ratio of foreign language journals to the total number of periodicals gives some indication of the breadth of scientific interest of the teaching staff. In U. S. A. in some colleges the library enjoys the status of a major department and medical librarians are employed to teach the students the use of the library and the method of obtaining knowledge of medical bibliography. These colleges feel that without an understanding of this the student cannot hope to carry on that independent study of medical literature which is essential not only to satisfactory undergraduate education but also to his continued education and experience after graduation. It is only by encouraging the study of current literature pertaining to the subject that the student can understand the present status of the subject and the future possibilities in connection with it.

In a recent survey of 66 medical schools in U. S. A. it was found that the average number of volumes was 20,000, the average number of periodicals was 272, and the average number of foreign language periodicals was over 10. In the ten highest ranking medical school libraries, the budget provided was over $7,230 per annum. On an average a student visited the library 65·7 times and used 25·5 volumes in one year.

Compared to the better class American schools, the library facilities provided by the Indian medical colleges leave much to be desired. For example, the number of volumes possessed by one of the best Indian medical colleges is only 16,000. The number of periodicals subscribed for is only 25. Foreign language periodicals are conspicuous by their absence. The budget allotment is only Rs. 1,500/- per annum. The practice of referring to current journals by students is not very popular. Libraries are mostly used by students who have no text books or by those who wish to consult books other than those they possess. All these can and will change only when students and staff are encouraged to undertake research and when the library gets a better budget allotment.

It is generally accepted that the practice of conducting journals by the students of medical colleges helps them to make use of the library properly. Indian medical colleges would do well to remember this and encourage journal publication by students more seriously than at present. If most of the existing college journals appear but sporadically and unenthusiastically it is because there is no organisation behind them. It is the duty of the staff to stimulate and guide the students in this regard. Few probably realise that if a journal is properly run it can be made always financially self-supporting. A limited number of regular subscribers and advertisers are all that is necessary to keep it going. To enlist these should not be a difficult task for any medical college situated in the larger cities of India.

Here mention may be made about the need for text books containing Indian data and reference to Indian problems. At present the foreign text books available in the country while being highly valuable in certain

respects lack information on local problems that the Indian medical student will be particularly interested in. If the professors of our medical colleges would only take the trouble to write suitable text books and incorporate in them all available Indian data and their own personal experience, a long-felt genuine demand will be soon satisfied.

Clinical Facilities

It is recognised all over the world that no medical college can function satisfactorily unless it has a sufficient amount and the proper kind of clinical material for teaching purposes. Attempts have therefore been made to fix adequate standards for this. The standard generally used is the number of beds available in the attached hospitals per student in the clinical years. Emphasis is also laid on the importance of a proper selection of cases to these beds and the admission to them of a wide variety of pathological conditions necessary for training. Usually the more common diseases in different stages of development are chosen for the benefit of students and the rarer conditions admitted with such frequency as would enable the students to recognise them when encountered later in practice. In a recent survey of 66 American medical schools it was found that the number of beds per student varied from 2·8 to 37·9 with an average of 14·2 beds per student. Admissions to these beds varied on an average from 10 to 20 cases per year and the average number of new patients actually in charge of a student in one year worked out to 152.

In India stress is no doubt laid on the importance of providing adequate clinical facilities for teaching purposes, but the level reached by the best Indian medical college is the same as the level obtained by the lower ranking medical colleges in U. S. A. In most of our medical colleges the ratio works out only to 2 or 3 beds per student and the number of cases in charge of a student in one clinical year works out to about 30. As for the conditions in the medical schools they are absolutely unsatisfactory in the majority of instances. In a country like India where laboratory and other aids to diagnosis are not too readily available except in the larger towns and cities and where these facilities are not within the means of the bulk of the patients, it is the clear duty of our medical colleges to give their students a sounder and more thorough training in clinical diagnosis. This they can do only when the number of beds in the attached hospitals is increased, when the type of cases admitted is primarily based on student requirements and when the training is so planned that it will be compulsory for the students and the staff to spend more time at the bed side than in the lecture room or the laboratory as at present.

Here it will not be irrelevant for me to draw your attention to one of the criticisms that is being levelled at our recent graduates by the senior members of the profession, namely, that the graduates nowadays are too much dependent on laboratory, X-ray and other findings and too little on the results of their own clinical observations. From personal knowledge of several of our recent products I feel that this is a very true and just criticism which our medical colleges would do well to note. Although in our educational programme we should and do rightly stress the importance of the scientific method of approach to medicine it does not mean that we would be justified in neglecting or in even laying less emphasis on the clinical methods of examination. All must admit that the art of medicine is as important as the science of medicine. India

cannot afford to ignore this for a long time to come. One of the causes of unpopularity of western medicine among the Indian masses is that it is too expensive; apart from the cost of medicines, there is not only the doctors' fees to pay but also the fees to the bacteriologist, the biochemist and the radiologist. I do not say for a moment that we should in our practice of medicine altogether omit resorting to laboratory aids, on the ground that they are costly. I certainly admit that they are essential and must be sought for confirmation of diagnosis and for guidance in treatment wherever indicated. But I do say at the same time that it is our duty to consider our patients' purse and to suggest these aids only when they are absolutely essential. The suggestion should be made after thorough clinical examination and when this has failed to help in arriving at a definite diagnosis or when there is a reasonable chance of the laboratory investigation proving helpful in providing the confirmation sought or in chalking out a special line of treatment that is contemplated. At least until India can provide free laboratory service to all as some the more advanced States in the west have done, we should teach our doctors to use their clinical sense more and to resort to laboratory aid only when and where necessary. This is a point that we must particularly bear in mind when we are training our rural practitioners who cannot hope to obtain too readily any elaborate laboratory facilities. For these reasons no over-emphasis is possible on the need for proper clinical training and for provision of adequate clinical facilities for giving that training.

The Staff

The staff of a medical college may be considered under two heads—administrative and instructional. The former is represented chiefly by the dean or principal and the latter by the professors, assistant professors, demonstrators and others. The experience of progressive institutions in western countries has shown that the standard of efficiency of a college and its product, depends ultimately on the quality of the staff. Their enthusiasm, energy and foresight, the type of contacts they make with the students, the reactions that these contacts set up in the students, the ideals the staff aim at themselves and those that they place before the students, determine largely the future of the college and of the men committed to their charge. Such being the case the selection of these is an onerous responsibility.

A recent report on medical education in U. S. A. defines the functions of a dean as 'formulation of educational policies, suggestion of educational practice, supervision of curricula and courses and of methods of instruction, selection of students and teachers, development of methodology for gaining approved objectives' and so on. It further says that the dean must 'effect, sustain and develop executive relations between the university and the school, administrative reciprocity between various departmental heads and himself, scientific leadership for the entire school staff and community leadership in countless problems involving education, community health and group welfare'. From these it necessarily follows that if a dean is to discharge these multifarious functions satisfactorily he must be (1) a specialist in medical education which is a well differentiated field today and be well acquainted with current medical educational problems; (2) he should be a scientist of a high order though it is quite immaterial whether he is a surgeon or a physician, an obstretrician or an ophthalmologist, a bacteriologist or a biochemist; and (3) he

must be a medical administrator and a leader possessing enough diplomacy, strategy and skill to contact other non-medical leaders, to enlist their support and to carry through his schemes for gaining avowed medical objectives.

In India many Indians have in the past occupied and are at present occupying the position of dean in our medical colleges. It would be no exaggeration to say that most of them have occupied the chair with as much dignity and fitness as any of the non-Indian deans. A few of them have even effected improvements of which they may well be proud. If they have been successful, it was either because they adopted diplomatic and strategic methods or because they wielded personal influence with their administrative heads. If others have not been quite so successful, it was not because they lacked quality, but possibly because, the limited responsibility, the restricted freedom of action, the chilling of the enthusiasm from repeated frustrations of sincere attempts at reform all induced in them a negative reaction and made them follow the line of least resistance. It is common knowledge that in India due to the peculiarities of the organisation, to effect a much-needed change is real uphill work. Only those who have tried know the difficulties best. India has no dearth of competent men to occupy the position of dean in our medical colleges. Mehtas and Mudaliars are not impossible to find. Even if the men are not available ready made, men of promise with the right outlook are available, they can be chosen and sent abroad to specialise in medical education ; they can be given greater powers and freedom of action at least in educational matters ; their suggestions and schemes can be considered more liberally and sympathetically and given fuller financial support both by government and the universities concerned. Unfortunately in India our universities have very little to say in matters pertaining to staff, policy and programme of our medical colleges. As it is the recognised function of universities to insist upon the highest ideals and standards being placed before the students and the right objectives being aimed at by the staff, our universities must not hesitate to come forward and share with the government the responsibility for providing medical education and for developing it on true university lines.

As regards the instructional staff, the American report to which reference was made previously, states that 'men with doctorate degree, teaching and research experience, training in foreign universities, originality, initiative, integrity and right outlook' should alone be selected. Realising that teaching is an art and comes naturally to some it lays special emphasis on the possession of teaching capacity. Certain institutions are even reported to go to the extent of finding out from among their students those with gifts for teaching and research, maintaining a list of them and offering them teaching jobs when they fall vacant. Security of tenure, decent starting salary and good future prospects are considered guarantees that will elicit the undivided attention of the instructional staff and at the same time ensure for the institute a steady progress in pursuit of its objectives. As the instructional staff are the ones that come into closest contact with the students and as they influence their future in more ways than one proper selection of these is considered to be of paramount importance and is insisted upon.

In so far as the instructional staff of medical colleges in India are concerned I have nothing much to say except that we should, as far as possible, follow the principles enunciated above. At this stage I like however to discuss two reforms relating to the instructional staff of Indian medical colleges which need to be immediately introduced in the interest

of medical education. The first is to debar the entire teaching staff from engaging in private practice in order that they may be able to give their undivided attention to teaching, research and hospital patients, if any in their charge. Past experience has clearly shown that the hankering after private practice by the teaching staff has been mainly responsible for the low educational standards attained in some of our institutions. The large volume of practice that the staff often secure by virtue of their position, makes it difficult for them to give their full attention to their legitimate official duties. Not only is the wrong attitude to medicine developed in the staff but also in the trainees who see the financial benefits that result from following wrong ideals. Another serious damage that has been done through allowing private practice to paid doctors in government employ in general and to the paid teaching staff of medical colleges in particular, is that it has kept down the standard of the independent medical profession through unfair competition. I say this because in India generally the better qualified men until lately got into government service. By virtue of the post they are in they readily obtain certain free facilities that the independent practitioner cannot get except at prohibitive cost to his patients. The practitioner is thus handicapped doubly and is unable to compete with the serviceman who is in an advantageous position. This leaves the practitioner often with no incentive to improve himself as he is not sure whether the money and time spent on improvement will bring in an adequate return. Therefore in the interest of education, in the interest of research and in the interest of the profession, no private practice should be allowed to those attached to teaching institutions.

To effect this reform without much discontent may be a difficult task. Those that have enjoyed this privilege for long will surely cry hoarse. But in the larger interests of the country we must put through this reform unhesitatingly and make the vested interests forego this objectionable and unjustifiable privilege. When that is done, it may be necessary to revise the scales of pay of our collegiate staff and put them on a more satisfactory basis. This would be well worth doing. The principle of disallowing private practice to the superior teaching staff of postgraduate institutes has already been accepted by government and given effect to. It can easily be extended to include the entire teaching staff of these institutes as well as those of the medical colleges.

The second reform that is needed is to constitute a separate cadre for the teaching staff of medical colleges. At present the college staff form part of the provincial medical cadre and as such are liable to be transferred to non-teaching posts. These changes apart from depriving the colleges of competent teachers may bring in men who have no aptitude for teaching and who cannot appreciatively co-operate in the educational programme of the college. The creation of a separate cadre will overcome this difficulty and help the colleges to achieve their objectives more rapidly. In this teaching cadre it should be possible through a well planned system of selection and training, for the lowest member to aspire for the highest post in course of time. If all junior appointments are made on the basis of competency alone, if opportunities are provided for specialisation abroad and if facilities are given for further development on their return, I have no doubt the cause of medical education in India would be better served. Teaching jobs are key jobs and they must be held by none but the best.

Now the question arises as to what should be our policy with regard to the appointment of honorary men in teaching institutions. My answer

is that as far as possible honorary men should not be appointed to teaching posts. This I feel is the right policy to adopt, though exception may be made in certain special cases where men in the top rank of the profession apply to clinical posts and give an assurance that they will devote the full time expected of them to the hospital patients, to the students and to research. I really believe that the proper place for employing honorary men is in all non-teaching hospitals in cities, towns and urban areas and wherever there is a reasonable chance of their obtaining a decent living through private practice and of their giving ungrudgingly of their time and service for a noble cause. I even believe that honorary men should replace the paid government doctors in suitable places according to a properly prepared plan but of course I would also take steps to prevent the converting of the government hospitals for the poor into private nursing homes for well-to-do patients through a system of proper government supervision and control. Adoption of such a policy would incidentally release lot of money which could be more profitably and equitably used by government in the rural areas. Lest I be misunderstood and considered unsympathetic to the cause of honorary doctors who have in many of our provinces contributed richly to the furtherance of medical education in the past, I might add that because we wish to raise our colleges to true university standards and because we require our teaching staff to utilise all their spare time for research and postgraduate training I feel it unfair to expect the honorary men to conform to these requirements and give us their best for no return except the satisfaction of whole time work. It is on account of this that I believe in the utilisation of honorary staff in places other than those connected with teaching institutions.

Students

Medical students represent the future medical men of the country. They may become administrators, teachers, research workers, specialists in one or other branch of medicine or general practitioners. To bear in mind the special requirements for these types and to select candidates suitable for each is indeed a difficult task. Nevertheless two questions that generally weigh in the selection of a candidate are : (a) has he had a suitable premedical education ? and (b) is he a fit person to be entrusted with the medical care of the people ? As regards the first, the minimum standard of premedical education required for admission has been fixed at the I.Sc. but the groups in I.Sc. that make one eligible for admission vary somewhat in the different medical colleges in India. If all our universities would create a special premedical group in I.Sc. in which chemistry, physics, biology and mathematics are taught according to a syllabus drawn up in collaboration with the medical authorities our purpose would be best served. All that would then be necessary is to see the marks obtained in the various subjects including English and to choose the candidate after interview according to merit. There would then be no further necessity to teach these subjects in any medical college except in their applied form in relation to any particular subject that is being taught. As regards the second question, it would be worthwhile for the selection committees to take a few hints from the Hippocratic oath which every doctor is made to take on graduation without even understanding what it really means. The oath implies that in addition to professional skill, the doctor should possess a high sense of responsibility, good moral character, integrity, understanding of human nature,

and profound sympathy with human suffering. If some of these qualities are known to be possessed by the prospective candidate, preference should of course be given to him. During the past ten years, I have, out of curiosity, enquired of a few hundreds of my graduate students as to the reasons that led to their taking to the medical profession. I have classified the answers I got into 6 categories—parents' choice 25%; tried for admission elsewhere but secured admission only in medical college 15%; relations were successful doctors 10%; their class mates joined medical college 15%; medicine was the most paying profession 30%; medicine was a noble profession 5%. The above results suggest in a way that the majority of our students do not study medicine with the right attitude.

In connection with the admission of students into our medical colleges, two questions have always been asked; namely, (1) are we admitting all the students we can train? and (2) are we admitting the right type that the country needs? A study of the number of applicants and the number of admissions into our medical colleges shows that usually out of every two to five that apply only one gets admitted. This proves that there is no dearth of youngmen desirous of taking up the medical course. If we are then really anxious to produce more doctors to meet the enormous demand we have two alternatives (1) to increase the number of colleges, or (2) to increase the number of trainees per college without of course lowering the standard of the education imparted. From our knowledge of the economic and other conditions in the country we may presume that it will be a long time before we can hope to be in a position to increase the number of colleges. We should be content if, when the conversion of medical schools into colleges is completed within the next ten years as at present contemplated, we are left with about 25 medical colleges in all producing approximately the same number of medical men per year as at present. This scheme in itself would cost the government about 3 crores of rupees in capital expenditure and about Rs. 25 lakhs in recurring expenditure over their present annual allotment for the 27 schools. Such being the case we need consider here only the second alternative, namely, the possibility of training more students per college without lowering the educational standard. This in my opinion is practicable and one which we should consider seriously. Russia has recently shown that more than one batch of students can be trained at one time in one college without much difficulty or extra cost and without lowering the quality of the doctors produced. A few years ago Russia had before her the same type of problems as we have—shortage of doctors, shortage of colleges, shortage of material equipment and money. In 1914 she had only 25,000 doctors in all; they were mostly licentiates and partly graduates, the proportion having been 3 : 1 and her educational facilities merely satisfied minimum standards in material, equipment and hospital beds. The last great war depleted even these poor resources. But through proper planning which began in 1925 Russia in 1940 came to possess 120,000 doctors of whom one-third were licentiates and two-thirds graduates. This improvement was effected chiefly through the introduction of the system of training in batches. By this method every college produced 2 to 4 times the usual number of doctors and maintained at the same time the original standard. The shortage of equipments, beds etc., was made good through a system of sharing, by 2 to 4 students of one article and using it at different times of the day or on different days as was convenient to arrange. The Leningrad medical school which is the biggest of the kind is said to

train 4 batches at one time through a system of shifts as in a factory. If the Leningrad system could be introduced in our medical colleges in a modified form to suit Indian conditions, I have no doubt that it would solve our difficulty of shortage of doctors at least until we are in a position to increase the number of our medical colleges. I suggest that when the new medical colleges are being created through conversion of existing medical schools this scheme should be seriously tried. Once private practice is disallowed to the collegiate staff they will have ample time to undertake the additional responsibility of training extra batches. At present the staff of a department usually devote for teaching about 200 to 250 hours in a year of 1,500 hours. Even supposing an equal number of hours is required for discharging other responsibilities, they can easily train two batches of students every year without great strain. All that will be required is to draw suitable time tables for the two batches. The extra financial commitment for a scheme like this will be negligible and I am confident that we can profitably introduce this system and produce double the number of doctors every year.

Regarding the question as to whether we are admitting the right type of students to meet the country's needs, I may state at the outset that the country's needs may be taken as three—urban need, rural need and the need for women doctors. The urban need may be said to be quite adequately satisfied by the type we are admitting and training. The only defect in the present organisation is that after graduation the practitioner does not obtain enough facilities for keeping himself up-todate through postgraduate training. This deficiency could be easily remedied by reorganisation of some, if not all, of our medical colleges so that they will be in a better position to arrange for postgraduate training. This can easily be done by remodelling one medical college in each province into a 'University Medical College'. I shall define later what I mean by a 'University Medical College' and what sort of a scheme may be readily put through without upsetting the existing organisation too much.

As regards the rural needs it must be admitted that they are not being satisfied at all at present. Although many attempts have been made to provide in the past medical aid to rural areas with the help of the men we have been producing in our colleges, no great success can be said to have been achieved so far. While some hold that the failure is due to the poor quality of the men we chose, others opine that the blame rests with the system of employment we adopted. I believe that both are at fault and particularly the men. Unless we recognise that the rural need is a different and distinct one from the urban need and unless we choose the right type of men for serving in rural areas and give them the appropriate training that will help them to tackle the problems readily and employ them under a scheme that will satisfy their legitimate aspirations, we cannot hope to solve the rural question. I have already defined what sort of men would serve best in rural areas—men with true missionary zeal, with sympathy and understanding, love of service, men efficient, upright and impartial. Such men won't be difficult to find if we look for them in the right quarters in the right way. I now add that these specially chosen men should be given a suitable training—a training based on a sound knowledge of rural conditions, rural problems and rural psychology. As our rural areas cannot afford to maintain a dual service separately for medicine and public health the men should be well trained in both. They should in addition also get enough insight into other rural problems to enable them to act

as true friends, philosophers and guides to the villagers. I say this because in our villages no improvement of any sort can be effected without the willing co-operation and whole-hearted support of the villagers themselves. The average villager through long continued suffering, fruitless attempts and frustrated hopes is naturally distrustful of all new schemes even if they are genuinely intended for his good, and he puts up invariably a negative attitude of resistance. This has to be avoided right in the beginning through winning over his heart by the men who would work in the village. To win his heart, the villager must be convinced that the men who are sent to serve him are not exploiters, and have not come to harass him but are real friends who are ready to help and advise him in all his difficulties, medical and non-medical. The villager must also be convinced that the men are not aloof or stuck-up, that they do not make too expensive demands upon his purse, that their knowledge of village problems and conditions are sound and that they are capable of applying their scientific knowledge in practicable ways to improve his lot. If this view is accepted, then it would mean that our rural medical officers must be not merely good medical men, but also good sociologists. Here I may add that Russia sends to the remotest villages the best men and not the worst as we do in India. I am giving later a scheme for the training of these rural medical officers.

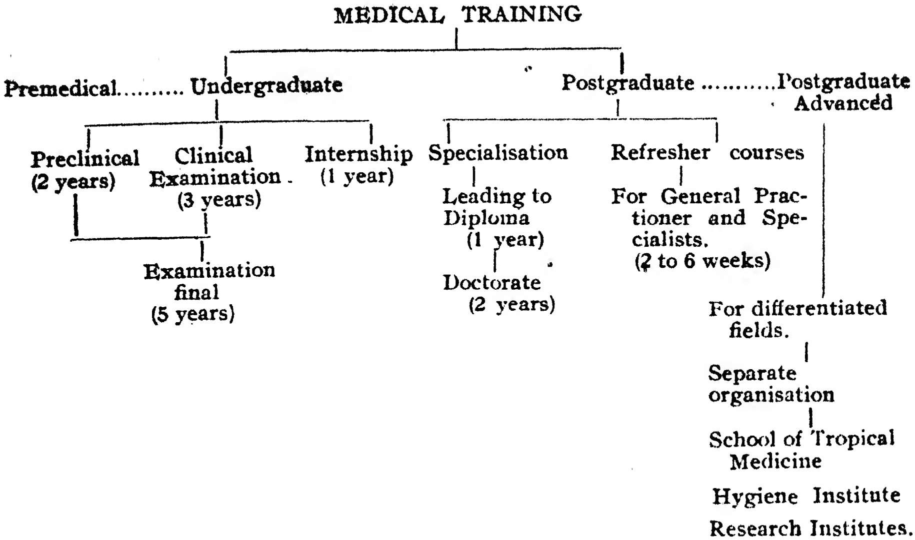
The third need I stated is for women doctors. It is superfluous to emphasise its importance. In India women doctors are particularly required in large numbers to meet the peculiar situation in the country. Although it is true that we have a medical college exclusively for women and that in addition we admit into all our medical colleges a few women students every year, yet the total number of women doctors in the country at present is quite small and utterly inadequate. Taking Russia, for example, we find that she has the largest proportion of women doctors (almost 50%) and that these have contributed in no mean measure to the building up of the new Russia which the world today holds in such great admiration and respect. India with her medical problems so closely intermingled with her social problems has a greater need for women doctors than even Russia has had and it would be no exaggeration to say that India can hope to solve her problems fully and successfully only through a larger number of women doctors. These have a special rôle to play in helping India attain her goal, and realising this Indian women should copy the example of their Russian sisters and enter the ranks of the medical profession in larger numbers and serve the country as patriotically as their Russian sisters have done. Our medical colleges in their turn should throw open their doors freely to women applicants and offer scholarships in sufficient numbers to attract the right type. And lastly the government must have a wider scheme for employing women doctors and for giving them ampler opportunities to serve the country in the right way.

Training

Medical training logically divides itself into two parts—undergraduate and postgraduate, and these in turn are further divisible as shown in the table on next page.

In connection with undergraduate training four questions generally arise, namely, (1) what should be the total period of training? (2) what should be the principles of training in the preclinical subjects? (3) what

should be the principles of training in the clinical subjects? and (4) what should be the nature and extent of internship?



Within the last 25 years there has been a steady tendency to increase the period of undergraduate medical training inclusive of internship. From four years it has now become six years and a few colleges in U. S. A. even recommends a 3-year intern period. This increase has been necessary for the inclusion of new subjects which have been developed as a result of recent advances in the various branches of medical science and for enabling the student to obtain a more thorough clinical training. While fully recognising the necessity for this longer period of training, educationists feel that an upper limit should be fixed once and for all. 6 years is now considered by most as the optimum limit and of these 5 years are recommended to be spent in actual training leading up to the final examination and 1 year to be spent after the examination as an intern or house surgeon. India would do well to adopt this recommendation uniformly in all her medical colleges.

During the period of preclinical training a number of subjects are taught which provide for the student the requisite background for the clinical training to be given later on. Unless these subjects are properly taught the student does not benefit fully from the clinical training. Within the last two decades many new subjects have been included ; and the present tendency is not to disallow such additions but to see that only the fundamentals are taught in them so that it will be possible to keep within the time alloted for the entire preclinical course. Here special mention may be made of four subjects that are being considered desirable nowadays, namely, Genetics, Nutrition and Dietetics, Statistics, and Sociology. The last is of special significance to countries like India where the health problem is closely connected with the socio-economic problem and where the solution of one is not possible without a simultaneous attempt at solving the other. As the aim of undergraduate education in general is to build a sound foundation in subjects such as anatomy, physiology, pathology, bacteriology and pharmacology, teaching in great detail is avoided ; only essentials are taught leaving details to be filled up later

as and when required. Also more time is set apart for teaching those aspects of the subjects as are likely to be of most value to the general practitioner. With this in view a wise discrimination is exercised in alloting the time to be devoted for a subject as also for the different aspects of the subject. For example, in bacteriology more time is spent in teaching the applied aspects than the systematic aspect. Media making, biochemical reactions, serological tests like the Wassermann reaction are only demonstrated. The students are trained to conduct simple examinations for helping them to diagnose their cases and are taught to interpret the results of the more elaborate tests. In view of the importance of bacteriology to both curative and preventive medicine the subject is taught from both these aspects. Not only is it presented from the point of view of pathology, clinical medicine and therapeutics but also from the viewpoint of aetiology, epidemiology and prevention. In planning the actual courses special emphasis is attached to practical work on the principle that "what we do ourselves we learn best and what we hear or see we do not learn so well". The optimum ratio of theoretical to practical training has been worked out and it is agreed that for every hour spent on theoretical lecture, at least 2 to 3 hours should be allotted to practical instructions. As the majority of the preclinical subjects require adequate laboratory facilities to enable one to give a suitable practical training, the requisite equipment and material are provided in proportion to the number of trainees.

Regarding the position of undergraduate medical training in preclinical subjects in India it is not possible for me within the time at my disposal to discuss the present status in each subject. I am therefore confining my remarks to one only, namely, Microbiology, as I am specially interested in it. Recently I had an opportunity to visit several of our medical colleges and to gather first hand information on the present position of microbiology in them. I found that there was no uniformity as regards period of training, syllabus, emphasis on preventive aspects and so on. As against an average of 176 hours spent by American medical colleges, India devotes only about 85 hours. The syllabus in microbiology is included partly under pathology and partly under hygiene and receives the treatment usually meted out to a minor undifferentiated subject. To quote one eminent authority, "Not only have the greatest advances in scientific medicine during the past fifty years been in the realm of microbiology, but it has also happened that the new developments in this field have been the most readily applied in clinical and preventive medicine". In undergraduate curriculum therefore microbiology is rightly included in the more important courses and given an independent status in all progressive colleges in the West. In India where two-thirds of the total annual deaths are caused by microbial agents and where there is a greater necessity than elsewhere for stressing not only the clinical but also the preventive aspect of microbiology it is surprising that even now no special emphasis is laid on the latter in most of our colleges during undergraduate training. This I presume is chiefly because microbiology is still tagged on to pathology and receives a predominantly clinical and not public health bias. To correct these defects we should create separate departments for microbiology in every medical college, revise the curriculum, bring it abreast of modern trends, and appoint competent staff with the correct outlook. It would also be desirable to create an association of Indian medical colleges.

The teaching of the clinical subjects is the major responsibility of undergraduate training. As the final aim of this training is to qualify the student to be an efficient general practitioner it is made as comprehensive

as possible within the time allotted to it. Apart from the usual fields that the student is made to cover, such as general medicine, surgery, obstetrics, ophthalmology and so on, a number of new subjects have been added such as pediatrics, psychological medicine, social medicine, history of medicine and medical ethics. During the period of training an attempt is made to give the student a thorough grounding in the general principles of the science and art of medicine and to teach him something in every one of the subjects that is likely to be of value to a general practitioner. Detailed training is given only in a few, as for example, in the diagnosis, treatment and prevention of the commoner diseases which are met with in general practice and enough is taught about the rarer diseases so as to enable him to suspect these in his patient and to refer the case to the proper specialist. The training given is not meant to produce a fully finished expert but a product with enough foundation for improvement at a later date through postgraduate training. The knowledge imparted is more practical than theoretical.

Apart from all these, the student is trained to develop the right attitude towards his patients and their contacts. He is taught to realise that the mental condition of his patients is as important as their physical condition. He is taught when to treat his patients with sympathy and kindness and when to be strict and enforce discipline. He is taught not to consider the patient as a mere store of a pathological condition but as an individual expressing a reaction to his environment in which social and economic conditions play an important part. He is taught to cultivate an interest in the personal difficulties and economic environment of his patients and to suggest that type of treatment which offers the best prospect of success. He is taught not to prescribe costly proprietary preparations for a man, who is struggling to exist and to bring up a family on the basic wage, when a cheaper pharmacological drug would serve the purpose equally well. He is taught that giving a prescription for an expensive medicine and instructions for a diet which is impossible of fulfilment are tantamount to professional neglect. He is taught that his responsibility does not end with the case but that he must also think of the contacts and learn to protect them through immunisation or in other ways. The value of preventive medicine is stressed through a proper training in its technic as applicable both to individuals as well as communities and through impressing upon him his obligations in this respect. And lastly he is taught that his function is not merely to cure and prevent disease, but also to help in maintaining positive health in the people. I am sure that India can profitably follow all these directions if she is not already doing so, particularly the last two.

One striking feature of most medical colleges in India is that their hygiene departments are not fully developed. A few of them do not even have a wholetime professor of hygiene. None of them have any practice field under their control where they can take the students for demonstration and field work. Just as one can only learn medicine in the hospital wards, surgery in the operating theatre, anatomy in the dissecting room and bacteriology in the laboratory, so also hygiene and preventive medicine can only be learnt in a well organised practice field. It is time that our medical colleges realised this and properly expanded their hygiene departments so that the preventive aspect of medicine and positive aspect of health might receive the emphasis which is their due.

It was not realised till recently that internship should be a basic part of undergraduate training and should be compulsory. Now most colleges are rightly considering it vital and withholding the issue of the degree and the license to practice till it is satisfactorily completed. The

object of internship is to give the final touches to the training of the candidate so that he may be better fitted to understand and treat his patients when he starts practice. The scheme of training an intern is planned according to whether the intern desires to become a general practitioner or a specialist in one or other branch of medicine. If the intern is a prospective general practitioner he is made to take his internship in any general hospital or under a reputed general practitioner recognised by the college; and if he is a prospective specialist he is asked to work in the appropriate department in the college or under a specialist practitioner who has adequate facilities for training him. During the period of internship, the candidate is not only allowed to be in charge of a certain number of beds or cases, but he is also given instructions through specially organised conferences, seminars and meetings at which, clinical, clinico-pathological, clinico-physiological, radiological, socio-economic and other problems, relating to the patient are correlated and discussed. Hospital as well as domiciliary methods of attacking medical problems are taught. The latter is considered to be of special importance to interns who are prospective general practitioners. It is generally agreed that the duration of internship should not be less than 1 year although in U. S. A. a 2-year period is being recommended. As regards payment to or by the intern it may be equitable to charge the intern a fee equal to one year's college fees and to provide for him free board and lodging during his internship.

All universities in India have not yet introduced the system of compulsory internship. If and when they do, nearly 2,000 doctors (at the present rate of production) will be continuously available practically free of cost and their utilisation will be of mutual benefit to the employer and employed. Through properly planned schemes for internship economy can be effected and efficiency increased. I suggest that we permit two types of internships, one in clinical subjects like medicine, surgery, ophthalmology and obstetrics, and the other in preclinical subjects like bacteriology, pathology, physiology and pharmacology. Although ordinarily internship means working in a hospital and developing greater contact and understanding of patients, their illnesses and their cures, it would be an advantage to enlarge its scope to include the second type. For those few graduates who intend becoming specialists in one of the preclinical subjects, it would be beneficial if they were allowed to work in the respective departments right from the time of their internship. While working in these departments they may be made responsible for collecting specimens for examinations, for attending clinical meetings and lectures organised for the benefit of all interns and for presenting results of small investigations of clinical interest which they undertake and so on. Even those who are doing internship in the clinical subjects should in addition to their hospital duties be made to devote their spare time to the study of one special disease in particular. They should be made to collect all data pertaining to the disease from the hospital records and from published literature and to submit a thesis. A satisfactory internship should mean steady work for one year in the hospital or laboratory and presentation of an acceptable thesis.

Postgraduate training is divisible into two parts—ordinary and advanced. The ordinary is again divisible into two types; (1) training of specialists in one or other differentiated field of medicine; and (2) giving refresher courses to general practitioners and others to keep them abreast of recent advances in their field. The provision of facilities for the ordinary type is now recognised as a legitimate responsibility of medical

colleges because the experience of progressive medical colleges has been that wherever postgraduate training has been organised the colleges have been able to provide a better standard of training to its undergraduates as well.

The training of specialists is generally designed in one of two ways—a short one lasting usually for one year and leading to a diploma, as in public health, obstetrics and gynaecology, ophthalmology, bacteriology, pathology, biochemistry, radiology and others ; and a long one lasting not less than two years and preferably three years and leading to a doctorate degree in one of the major clinical and public health subjects. While the diploma courses emphasise chiefly practical work in the ward, laboratory or field and limit the time spent on theoretical instruction, the doctorate courses stress both the theoretical and practical aspects equally and in addition insist on research work of some kind.

The refresher courses are separately designed for general practitioners and specialists. These courses are usually of a short intensive type in which theoretical instruction pertaining to the recent advances followed by demonstrations form the special feature and practical instruction is given only where considered important. The duration of these courses generally is from 2 to 6 weeks.

For the advanced type of postgraduate training separate post graduate institutes are generally established. In these, training in the special branches of the differentiated fields is given. Such training is intended to enable a person to become an expert in the branch and be capable of undertaking independent work and conducting research. For example, malariology, tuberculosis, medical entomology, applied bacteriology, epidemiology, statistics and other subjects have assumed such vast proportions that facilities have to be provided for training in these separately. The special institutes that have sprung up for these have generally three functions, namely, teaching, advice and research ; of these the second and third are considered major responsibilities. The staff is composed of men of superior calibre ; their teaching duties are limited and take up only a small portion of their time. Their main duties are to give advice on all important scientific matters pertaining to their speciality if and when sought for and to undertake research on problems of national importance.

In India the position with regard to postgraduate training facilities may be summarised as follows : Practically all the universities offer M.D. and M.S. but the standard of these is not the same as that of the better class British or American universities. This is so because our colleges do not provide training of a true university type as is done generally by the foreign colleges. Before one gets a doctorate it is reasonable to expect him to possess a thorough knowledge of his own subject and also a breadth of knowledge on all sciences as they affect his speciality. Our colleges do not ensure the latter always. Doctorates in other medical subjects are not yet organised.

Diploma courses in public health are being given in Madras, Bombay and Calcutta but only about 60 graduates take it every year. For a country like India faced with a public health problem of a stupendous magnitude requiring many thousands of qualified men, the above number is but a mere apology. Through reorganising and equiping the hygiene departments of medical colleges, which with a few exceptions are poorly developed specially with regard to field training facilities, a much larger number of graduates can be trained in public health each year. If the medical colleges in Madras and Bombay can give the diploma, I do not see why the colleges in other provinces cannot follow suit. But the real problem

then will be, "Who is to utilise the services of these men?" India has started only recently to be public health-conscious. She has all along been pinning her faith on curative medicine. Her demand for men trained in public health has just started and it is being taken care of by the small number of persons taking the diploma every year. But these will be inadequate when the demand grows as it should sooner or later. Organisations like the All-India Institute of Hygiene should really be functioning as advanced postgraduate institutes for training and research in the various differentiated fields of public health. It may for a time undertake, as a temporary expediency, to train public health personnel of the diploma standard as at present but it should soon grow out of it and provide facilities for advanced training only. Its major responsibility should be research on problems of national importance and giving expert advice on all matters pertaining to public health.

Diploma in tropical medicine is offered at the School of Tropical Medicine, Calcutta. This function really belongs to the departments of medicine in our medical colleges; India is a tropical country and tropical medicine should be the major concern of the departments of medicine. If these departments are properly enlarged and organised the School of Tropical Medicine can be made, as it should be, to undertake advanced postgraduate training in the various differentiated fields of tropical medicine. As an interim measure, the giving of the diploma by the School of Tropical Medicine has been highly helpful but its real status should be that of an advanced postgraduate school.

Diploma in obstetrics and gynaecology is being offered by the Giffard School in Madras. The number of candidates taking the diploma is as yet only few. The need for properly trained graduates in this subject is really great, specially as maternal and infant mortality rates are alarmingly high in India. It would be highly desirable to make it compulsory for every woman doctor to take the diploma course before setting up independent practice or entering service in a women's hospital. The creation of schools of obstetrics in every medical college is an urgent necessity. Pending that development, the Giffard School that has given the lead in the right direction may be more fully utilised to the best advantage by all provinces.

Diploma course in ophthalmology, radiology, bacteriology, biochemistry and others, need badly to be organised. These could easily be arranged with the available facilities and without much extra cost. Only a revision of policy is required.

Refresher courses for the general practitioner are not yet available in India. As a consequence the knowledge of the average practitioner is rusty, his outlook restricted and his standard low. India can correct this readily by reorganising some of the larger hospitals in cities and towns not attached to medical colleges, staffing them with honorary men and making them give these refresher courses to practitioners. Two or more courses may be arranged each year and the fees charged may be given to the honorary men. It will act as an incentive to the better class men to offer their services to these hospitals in an honorary capacity and as teachers.

Rural Medical Officers

So far I have been discussing medical training under the usual headings. I wish now to discuss specifically the training of the rural medical officers for India. I have all along during this address stressed the need for a special type of rural medical officers and here I like to

present a scheme for training these men. At the very outset I wish to point out that the scheme is a tentative one given purely with the object of stimulating thought and discussion.

Every one is agreed that our villages and villagers are in a miserable plight and need to be urgently improved. Intellectually, financially, physically and physiologically the villager may be said to be absolutely "down and out". Various schemes have been and are being tried for the amelioration of his condition and in these schemes medical and public health relief measures are also included. From the experience gained the consensus of opinion is that at the periphery India cannot afford ever to maintain a dual staff, one for medicine and one for public health although higher up this differentiation may advantageously persist. This means that for rural areas we need a large number of men with the dual qualification in medicine and public health with a special knowledge of village problems and their solution and with a genuine desire to work in rural areas. The question is how are we to find, train and employ these men. The scheme I have in view may be briefly outlined as under.

No scheme of rural medical relief will be successful unless it takes into account three aspects connected with it, namely, selection, training and employment of the right type of rural medical officers.

Selection of the men should be based on competence. Men possessing the qualities already described as desirable should be chosen. Men of the district or province where they are likely to work should be preferred. Women if available should be welcomed. As the right type of men may come forward only if financial assistance is offered, the training should be free. The cost should be borne by Government as in the case of I.M.D. students. If as suggested previously, the batch system of training is introduced the actual cost to government will be negligible. Scholarships may have to be offered to cover the cost of board and lodging during training. This may be borne by the prospective employer, District Boards or by philanthropic persons interested in rural medical relief or by Government from funds earmarked for rural reconstruction. The trainees in return should agree to serve wherever posted in rural areas for a minimum period of 10 years on a fixed scale of pay and free quarters.

The initial training will be the same for 5 years as for M.B.'s but during the internship period a special combined clinical, public health and sociology course lasting 1 year will be given. The clinical training should include minor surgery, first aid in emergency, tropical medicine, normal obstetrics and common eye diseases. Easy methods of diagnosis, cheap and efficient methods of domiciliary treatment should be taught. This should not take more than 3 months. The public health training should include, (1) simple methods of improving rural water supply, housing, sanitation and roads, (2) control of malaria, bowel disease, small-pox, plague and Kala-azar if prevalent, and hookworm, (3) methods of supplementing and balancing diet, infant care and feeding, (4) rural administration and laws, (5) methods of organising village self-help and co-operative health societies. This should take not more than 6 months. The sociology course should include, village society, village psychology, village economics and its relation to agriculture, poultry farming, cattle breeding, fish rearing, cottage industries, irrigation and others.*

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* The responsibility for giving the training should ordinarily rest with the hygiene department of a "University Medical College" in collaboration with the other departments. But as university medical colleges have not yet come into existence in India the All-India Institute of Hygiene may be asked to organise the

After successful completion of the training, the men should be employed in rural areas in the scale Rs. 100—5—150 with free quarters.† They will serve for a minimum period of 10 years. They will give free service to all in their jurisdiction which will not exceed 2,000 people. At the end of 10 years the option to leave service will be given. If they so desire, their work will be reviewed and if satisfactory their name will be registered for employment in regular government service. In addition, they will be given free postgraduate training in any subject that they choose to specialise in and for which facilities are available. The period of free training will not exceed one year and the object of this training will be to enable them to set up independent practice. These two concessions will act as incentives in a way for good work during the ten-year term. Russia which has extensive rural areas like India has solved her difficulty in somewhat similar way and it is for India to try an experiment on the same lines but modified to suit her peculiar conditions. The government is already adopting a similar scheme for solving their military problem (I.M.D.'s) ; it is only a question of extending it to solve the much harassed rural problem.

'University Medical College'

In the course of my address I have in several places used the term 'University Medical College'. I wish at this stage to say a few words as to what is meant by it. A study of the various medical educational institutions in existence in different countries of the world shows that they may broadly be classified into two types—ordinary type and university type. The first type is organised chiefly to produce the ordinary general practitioner through provision of facilities for undergraduate training of a vocational type; and the second is organised not only to produce the general practitioner with a scientific bias but also the specialist in various branches through provision of facilities for postgraduate training and research. The objectives aimed at and the functions of the various departments are also different. In order to enable one to picture these two types correctly I have represented diagrammatically the functions of the department of microbiology in the two types (*vide* Table on next page).

The modern tendency is to have wherever possible medical college of the University type which in the words of Abraham Flexner "would address itself whole-heartedly and unreservedly to the advancement of knowledge, the study of problems from whatever source they come and the training of men all at the highest level of possible effort". India needs a few of these. Almost all her colleges are of the ordinary type and a few are struggling towards the university type. These few can readily be remodelled into the university type and let us hope we will be able to do it in the near future. As I stated previously, the colleges in Madras, Bombay and Calcutta are advantageously placed and have already facilities developed to an extent that it would not cost much to reorganise them into the university type. The three together would require about Rs. 60 lakhs for capital expenditure and about Rs. 10 lakhs for additional recurring expenditure. This sum is nothing compared to the benefits that are likely to accrue from such reorganisation and expansion.

course, draw up a suitable syllabus, obtain the help needed from the School of Tropical Medicine and the medical colleges, and train the men on an experimental basis for a few years.

† The money for this will have to be provided by the villagers through some form of special taxation. A recent survey has shown that on an average one rupee per capita is being spent by the villager on medicines.

ORDINARY MEDICAL COLLEGE

FUNCTIONS OF A DEPARTMENT OF MICROBIOLOGY.

- Teaching
  - Undergraduate
    - Medical
      - Microbiology as applied to clinical medicine.
    - Public Health
      - Microbiology as applied to Epidemiology. (Not always stressed).
- Service
  - To hospitals attached to College.
    - Diagnosis
    - Autovaccine.
- Research.
  - Routine as applied to clinical medicine may be done. (Not stressed).

UNIVERSITY MEDICAL COLLEGE

FUNCTIONS OF A DEPARTMENT OF MICROBIOLOGY.

- Teaching
  - Undergraduate
    - **Medical Microbiology as applied to clinical medicine.**
    - Public Health Microbiology as applied to epidemiology. (Stressed).
  - Postgraduate
    - Leading to Diploma and Degree.
    - Special research training.
- Service
  - To hospitals attached to College.
    - Diagnosis
    - Autovaccine.
  - To urban and rural areas under control.
    - Diagnosis.
    - Water analysis.
    - Immunisation.
  - To outside agencies. (Consultative)
    - Advice, Help on problems of scientific or national interest.
- Research
  - Routine
    - Applied
      - Investigation of clinical and public health problems.
      - Development of methodology by students assisted by staff (Compulsory).
  - Special
    - Basic
      - Advanced problems by staff. (Compulsory).

The scheme of reorganisation I have in view is somewhat as follows :—

The control of the 'University Medical College' should rest with a board constituted for the purpose. It should be composed of two representatives each from government, university, legislature, postgraduate and research institutes and the medical college itself.

The duties of the board should be administrative, financial and technical control.. Appointment of staff ; finance ; building ; equipment ; creation of new departments ; expansion of existing departments ; formulation of policy and programme ; organisation of new courses of study ; formulation of regulations and rules ; determination of fees and scholarships ; acceptance and utilisation of gifts ; bequests and trusts, should all come under its purview.

The university concerned should help by (*a*) providing regular grants towards the cost of research and postgraduate educational programmes, (b) creating endowment fund by attracting public support, (*c*) enabling the college to utilise some of the facilities of the university for their educational activities, (*d*) broadening the objectives and procedures of medical education and (*e*) encouraging the publication of books on medical subjects containing Indian data and information.

The government will continue to give financial aid as at present but will delegate some of its powers to the board of control.

FINANCE

To place medical education on a sound footing we require adequate finance. The two questions that arise in that connection are, what are the sources of income of medical institutions and how are they supplemented? The sources of income of medical institutes may be (1) fees from students (2) grants from government or university or both and (3) endowments from philanthrophic individuals. The amount of income derived by way of students' fees varies in different institutions but it rarely ever covers more than about 25 per cent of the maintenance expenditure ; often it is much less. Dependence on this source is therefore futile. The Government and the university generally provide recurring grants to most medical institutions. These grants cover wholly or in major part all normal expenditure. Wherever State aid has been insufficient, endowments from private sources have been freely received. A recent survey in U. S. A. indicates that education and research in medicine and public health receive from private endowments 12.3 million dollars annually. The latter in fact have been responsible for the rapid progress achieved by many institutions. The princely endowments of Rockefeller, Kellogg, Carnegie, Nuffield and others to educational institutions and the influence these grants have had on modernising them are known all over the world.

In India of the 37 medical colleges and schools, 27 are government owned and the others receive government aid in one form or another. Though the government spends a large sum of money on medical education, progress is slow because university grants and endowments by philanthropic persons are not quite adequate. This war has opened our eyes to one fact, namely, that India can raise huge sums of money for a good cause. As there can be no better cause than that of medicine and the alleviation of human suffering, it is for India to raise the necessary funds for the purpose. If the medical colleges with the consent and support of government can make the proper approach to the right type of persons, I have no doubt that ample funds will be forthcoming. The Princes, Maharajas, Rajas, industrial magnates, merchants, will all have to make benevolent contributions to this good cause.

FUTURE

So far, I have been discussing the various aspects of medical education and giving tentative suggestions for development or improvement in certain directions. Now, all that remains to be said is; something about the future. It is indeed very difficult for anyone to foresee what sort of a world will emerge out of the present turmoil, and what sort of a political, social and economic India will spring up. It is also difficult to foretell if and when any scheme for improvement and development, either in the form suggested or in some other modified form will be given effect to. Whatever may happen, one thing is certain and that is the future of medicine in this country will largely depend upon the attitude taken by the government, the medical profession and the public (1) on the indigenous and other systems of medicine (2) on the type of medical service and (3) on the basic premedical causes of ill-health, namely, poverty, ignorance and lethargy.

If one goes into any rural area in this country (this is also true of many urban areas) one finds four classes of practitioners—the witch doctor, the quack doctor, the *ayurvedic* or *unani* doctor and the allopath. As regards the first two, all are unanimously agreed that quackery wherever and in whatever form it exists must be relentlessly put down. Yet we have so far done nothing substantial to root it out nor even to make it difficult. It is being practised openly and it still remains a challenge to scientific medicine and a blot on human intelligence. We must make up our minds what to do about it.

As regards the *ayurvedic* and *unani* systems the opinion is rather divided. There are some who believe in retaining and encouraging them ; there are others who wish to adopt a neutral attitude, and yet others who feel that these systems have ceased to serve a useful purpose and should be scrapped. These differences have led to the adoption in general of a neutral attitude to the indigenous system. This I am convinced is very harmful not only to the cause of indigenous medicine but also to the cause of scientific medicine. If we want the indigenous system to remain, we must encourage it as best we can, get the qualified men compulsorily registered so that quackery may not masquerade under its name and spoil its reputation as it is doing at present, and also make the services of these men readily available to the people wherever they are required. All this is possible, but if it is done, it will, in my opinion be a false and retrogressive move, a move in the wrong direction. If really India wishes to keep pace with modern developments in science and come into line with all advanced countries, she must, however unpalatable it may be to some people, be prepared to abolish this antiquated, empirical system of medicine. Any sympathy or attachment to it will only retard scientific progress. The plea that the indigenous system is better suited to Indian constitutions is a myth. The plea that it is cheap and within the means of poor people is no criterion of its value or usefulness. The plea that it is readily available even in remote areas is a dope to ease the conscience of the sick for whom we are unable to provide the scientific medical aid that we ought to. Under these circumstances we must make up our minds as to what to do with these systems of medicine.

The position at present with regard to the allopathic system is that all people resort to it when they can obtain it and if it is within their means. The majority of the people are thoroughly convinced of its greater value and usefulness and its wider application in many fields. It has the advantages of possessing a preventive side, of having methods for developing positive health and of being built on rational and scientific basis.

How much we need of it and what sort of support we wish to give it, we must make up our minds as well.

The type of medical service that is best suited to the country has also to be decided. Each country has developed the type that, under the conditions prevailing in it, has given ideal service to its people. To introduce blindly any one of these types into a country like India hoping that it would succeed is tantamount to courting failure. We must study beforehand the situation in the country thoroughly with the help of an expert committee and find out the type of medical service that will really and truly take the benefits of modern scientific medicine within the reach of every individual in the country, urban and rural. I believe even with the existing resources in men and money we can reorganise our medical services in a way such that they will be of greater help to a larger group of people than at present. As I stated previously, through the utilisation of the services of honorary men in place of paid men in all urban areas and through the employment of paid staff in all rural areas where they are badly needed we can greatly improve matters. The type of organisation I have in view consists of 5 classes of officers: (1) administrative officers in each district for direction, supervision and control, (2) medical college staff for teaching, research and technical advice, (3) rural health officers for doing mainly public health work and a little of medical work, (4) honorary doctors in all urban hospitals for medical work and (5) health officers of municipalities and towns. Once it is agreed that a particular scheme is suitable, then medical education can be immediately modified to supply the type or types of doctors required for the scheme. We must make up our minds as to the type of medical service that would suit the country best.

Lastly it has to be realised that the medical problem is closely connected with the social and economic problems. Unless we stamp out the basic premedical causes of ill-health, namely, ignorance, poverty and lethargy, we will never be able to attain any measure of success with any of our medical schemes. Although the abolition of these is not directly concerned with medicine, yet for achieving our final object of raising the standard of health to a high level, we must get these rooted out. In India the ignorance of the masses due to lack of education is unparalleled; the poverty due to low incomes is apalling; lethargy due to lack of employment is colossal. No one can ever hope to build on such flimsy foundation any edifice of health and well-being. We must make up our minds as to the ways and means of remedying these basic defects.

These then are some of the problems, on the solution of which the future achievements of medicine in this country largely depend. They may at first sight seem stupendous and difficult to solve and on that account the future may look a bit dark and depressing, but I have no doubt that with the right policy, right programme and right action all difficulties can be overcome and the lives of millions of our village people changed from one of misery and despair to one of happiness and hope.

Conclusion

The time at my disposal being limited I have attempted to give a bird's-eye-view of the vast subject of medical education as it appears to me. While there is no doubt whatsoever that the progress and the achievement of the last hundred years have been great and commendable, yet it has to be admitted that there is ample scope for further improvement and expansion in several directions. If we can let knowledge determine our policy,

if we can make science guide our programmes, if we can have justice as the motive power of our actions and if we can act without fear or reserve or consideration for useless tradition or interested parties, we can carry the torch of progress faster than hitherto towards our goal of health for all.

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SECTION OF AGRICULTURAL SCIENCES

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SOME ASPECTS OF THE PRESENT AND POST-WAR FOOD PRODUCTION IN INDIA

(Delivered on Jan. 4, 1944)

It is with great pleasure I welcome you to the Section of Agricultural Sciences of the 31st Session of the Indian Science Congress. Further I wish to express my heartfelt gratitude to my fellow workers and friends for having done me the signal honour of electing me President of this Section, and I regard it as an appreciation of my humble services to the cause of agriculture for the last 30 years. That does not mean that I am not conscious of my shortcomings or that I am oblivious of the fact that I have to maintain the traditions set by my illustrious predecessors. It is in the spirit of service to Science that I have accepted the responsibility and I crave your indulgence.

The influence of the present world-wide war on the production and supply of food in our country having assumed a very serious importance at the present moment, this subject is naturally uppermost in my mind and I have therefore decided to briefly record some of my views in this connection.

PRE-WAR (1935) PRODUCTION AND SUPPLY OF FOOD IN INDIA

According to the calculations based on the calorific requirements of the population and on the capacity of the area under cultivation in India to meet these, it has been shown by Mukerjee[17] that during the year 1935, nearly 48 millions of the population representing the average number of persons, had to go without food on the assumption that the rest of the population, which was about 320 millions, obtained their basic minimum ration.

On a study of the figures of imports of food grains from Burma and foreign countries during recent years, Gyan Chand[15] has shown that India has of late become, to an increasing extent, a food-importing country, the imports amounting to about 2 to 2·6 million tons, and India's own food supply has thus fallen short of her requirements. He further states that although the increasing volume of imports of food grains may be taken as a sign of increasing commercialization of the economic life of the country, the fact remains that in spite of India being predominantly agricultural, she is now importing increasing quantities of food grains, and the situation briefly explained in his own words is,—"India is a country of teeming millions and they are wretched and racked by hunger and despair. Their position has to be retrieved if they are not to be driven from blank despair to maddening desperation."

Prominent Indian politicians also often mention that there are millions of starving half-clad people in India who have to remain content with either half or one meal a day. It will thus be seen that on this problem,

unanimity of opinion exists among the different sections of the thinking public.[23]

PRESENT-DAY POSITION

According to the 1939-40 figures,[16] area under cereal crops like rice, wheat, maize, *jowar* and other millets in British India, is about 146·6 million acres and if it is assumed that the production of crop is normal as per standard out-turns fixed for the various crops, we should expect a gross out-turn of consumable produce of approximately 55·8 million tons. Allowing about 2·6 million tons of this produce for seed purposes, the quantity of cereal food grains available for human consumption comes to 53·2 million tons. Figures relating to British India only have been taken as those relating to the Indian States were not available to the full extent.

Taking the latest census figures, the population of British India in terms of average adult individuals (two children under 12 years of age being roughly considered to be equal to one average adult individual for this purpose) is about 236·6 millions. A basic minimum ration for an adult individual, according to Aykroyd[2], should provide 15 ozs. of cereals, 3 ozs. legumes, 2 ozs. fats, in addition to 8 ozs. of milk and 12 ozs. of vegetables and fruits, giving a total energy value of 2600 calories per day.

It is a well-known fact that a very considerable proportion of our population never takes any milk at all and the intake of oils as well as meat per head per day is also negligible, showing thereby that the required minimum calorific value must therefore be derived from the staple cereal food grains. Calorific value of cereals as a whole may be taken to be equal to 350 calories per 100 grams. Average requirements in respect of cereal food grains per head per day would thus come to 1½ lbs. on the assumption that about 275 calories are derived from oils, pulses, etc., as shown by diet surveys,[3, 10] and 1¾ lbs. if the total calorific requirements are to be derived chiefly from cereals only. On this basis, total quantity of cereal food grains required will therefore amount to 57·8 to 67·5 million tons which is higher by 4·6 or 14·3 million tons respectively than what the land can normally be expected to produce under existing systems of crop production ; in other words the present production from the existing area under cereal food crops will have to be raised by 8·6 to 26·8% in order to meet the minimum food requirements of the population. Taking the present population of India including that of the Indian States at 389 million or 311 million in terms of average men, the position in respect of food production to-day would thus appear to be worse than that described by Mukerjee, Gyan Chand and others some 6 years ago as the then estimated total population was about 377 millions which when converted into average men was equal to only 301·6 millions, and as is well known, increase in the area under food crops and normal yields have not been proportionate to this increase in population.

When we take into consideration the fact that, factors like seasonal fluctuations, wastage during processing, transit and storage, quantity of food grains consumed by poultry, agricultural and other animals, etc., have not been accounted for in the above calculations, the deficiency in respect of food grains even in normal times must be more acute than what has been shown, and it would be still worse in years of famine as there would be no appreciable surplus produce left over annually to build up any reserves as an insurance against famines.

The argument advanced against the position of import of food grains is that the increasing volume of imports is a sign of increasing commercial-

ization of the economic life of the country. In ordinary peace times we may have been able to import foodstuffs in exchange of non-food or commercial crops but this reliance on imported food grains has made the position of India precarious in the present abnormal state of the world. The present appalling conditions in respect of food scarcity in certain provinces should be a good eye-opener and bring home not only the immediate but the everlasting need to adjust our food production in such a way as to make India not only self-sufficient but also to provide for an adequate surplus as a margin of safety in abnormal years, which quantity can be available for export in years of normal production.

That a country like India, which is predominantly agricultural should be dependent on imports from other countries to meet the food requirements of her population is, to say the least, very unsatisfactory. We have enough land and our first and foremost aim of crop production should be to ensure above all the minimum requirements in respect of food and clothing for every individual citizen.

Suggestions to Ensure Immediate Maximum Food Production

It will thus be evident that leaving aside questions like birth control and other measures for checking the growth of population, our immediate need is to increase food production to the maximum extent possible, apart from the economic factors governing crop production. Maximum capacity of soils of different regions or tracts in regard to crop production depends on various factors of which climate, soil type, soil fertility, quality of the seed and incidence of disease may be considered to be of outstanding importance. It therefore naturally follows that in order to secure maximum out-turns of crops, these various factors must either be most favourable in relation to the general crop production of various regions or tracts or, in the alternative, cropping systems should be so adjusted as to derive maximum benefit from the existing factors. This raises a number of issues which, though it is not possible to discuss at length, are briefly dealt with below.

Climate.—Although we cannot exercise any control over the climate, deficiency of soil moisture can, to some extent, be made good by provision of irrigation facilities and a scheme should be drawn up for this purpose to encourage construction of wells in areas possessing a fairly shallow water table. Soil moisture can also be controlled by the provision of adequate conservation or drainage, and various regions or tracts should, therefore, be surveyed for this purpose and comprehensive schemes for the construction of bunds and drains should be drawn up. The State should play its part in putting these schemes into operation and sufficient funds should be made available to the cultivators at low rates of interest, together with a provision for adequate subsidies and easy instalments for the repayment of loans.

Soil types.—The practice of utilizing apparently unsuitable lands for a particular crop is in many instances responsible for the low yields in certain localities. It is, therefore, essential to see that only such crops as are suitable for particular soil types as well as for soils according to their position factor are grown in the various tracts. Special village surveys for this purpose would be necessary. Lands, which are considered to be below standard for production of arable crops, should be diverted to pasture or tree growth and steps should be taken to improve the yield and quality of the herbage and trees to be grown thereon as well as those grown on the existing areas.

Soil Fertility.—Soil fertility is dependent principally on (*a*) appropriate physical condition of the soil and (*b*) presence of adequate quantities of nutrient substances required for crop growth. Optimum physical condition of the soil depends upon the presence of right proportions of various mechanical constituents like, clay, silt and sand, and in addition, an adequate proportion of organic matter and lime. Data regarding analyses of soils and yields of crops from various manurial experiments dealt with in detail elsewhere clearly show that Indian soils are generally deficient in organic matter and nitrogen, and have now reached a stationary state of fertility at a low yield level [1, 6, 7, 13, 14, 21 & 22], as a result of cultivation for many centuries, without adequate returns of organic matter and phosphate, and due to the lack of proper soil management in certain important directions. Judging the results of various manurial experiments it can be stated without any fear of contradiction, that applications of moderate quantities of nitrogen i.e. 15 to 25 lb. per acre, as farmyard manure, oil-cakes or artificial fertilisers, raise the yields of common field crops like cotton, rice, wheat and *jowar* to the extent of 25 to 33 per cent. In this connection it may also be mentioned that the full value of bulky organic manures is not returned in one year but their beneficial residual effects on crop growth are visible over a number of years after the applications of manure are stopped.

It is, therefore, clear that special efforts must be made to improve the organic matter status of the soils. This can be achieved to a large extent by encouraging the preparation of composts from farm wastes by the cultivators and the preparation of composts from town refuse and night-soil in urban areas. As there is a considerable amount of prejudice amongst the cultivators against the use of composts prepared from night-soil and town refuse, the question of issuing this material free for a few years in the beginning and, in addition, making small cash payments to the cultivators to partially cover the expenditure incurred in carting the manure from urban areas to their fields deserves very careful consideration.

With a view to maintaining the fertility of soils in general and their nitrogen content in particular, extensive cultivation of leguminous crops by developing suitable crop rotations and mixed cropping practices to meet the requirements of various regions or tracts is urgently required. The nitrogen recuperative power of some common legumes when grown singly and in rotation, with other crops has already been dealt with elsewhere.[5, 8 & 9]

According to the requirements laid down for a properly balanced diet, minimum intake of pulses per adult individual per day must be 3 ozs. and the cereal protein/legume protein ratio should be about 1·80. Total area under gram and other pulses in British India comes to 40·5 million acres which will normally yield 8·7 million tons of legumes. Out of this 0·7 million tons would be required for seed purposes leaving a balance of 8 million tons which would yield about 5·3 million tons of pulses. On the basis of the population in terms of average adult individuals (236·6 millions) the quantity of pulses available per head per day therefore comes to only 2·2 ozs. as against the minimum required quantity of 3 ozs. Diet surveys[10] carried out in the C. P. & Berar have also clearly shown that average intake of pulses per consumption unit per day is 2·1 to 2·5 ozs. in the case of workers employed in cotton mills and manganese mines, and 2 ozs. in the case of cultivators.

In addition to the factor of minimum quantity of protein required per head per day, the biological value of the proteins, the importance

of a small excess of proteins with a view to (i) accelerating the general vital processes of the body, and (*ii*) restoring the loss of proteins involved in the production of certain products like hair, nails etc. cannot be ignored. It will thus be seen that the amount of protein which is available for human consumption in India is definitely inadequate and apart from the soil renovating power of legumes, extensive cultivation of these crops is therefore of urgent and vital importance in order to improve the existing ill-balanced diet of the people.

Quality of the seed.—Without going into actual details of yield data of various experiments conducted in the past, it can be said that the existing yields of common field crops are in many cases capable of being increased by 10 to 20 per cent if improved varieties of crops are grown in place of the local ones.[19] Selection of sound and healthy seed with good germinating capacity is also a very important factor which is intimately connected with the yields of crops. Efforts should, therefore, be made to immediately increase seed multiplication centres to meet the demands of the cultivators for improved seeds of various crops. The present strength of seed farms and plots is quite inadequate, and in order to meet the demand in full for improved seed, a network of Government and private seed farms together with suitable organisation for distribution of seed is of paramount importance.

Incidence of disease.—It is a well-established fact that crop yields are considerably affected from year to year due to the diseases caused by insects,[4] fungi and other causal organisms. It is therefore necessary to establish suitable agencies on a regional basis to deal with the diseases of crops, as individual efforts by a few cultivators in this direction do not always meet with success, and elimination of a particular disease or a pest from the tract as a whole is absolutely essential to save the crop or crops of the locality.

Breaking up fallow land.—One of the methods suggested at present to increase the production of food crops in India is to break up fallow land. In this connection the position of the cattle *vis-a-vis* the human population must be very closely examined. Do we secure better production of food and fodder for the country as a whole by bringing new land under cultivation than by adequately manuring and cultivating the existing lands on an intensive scale and developing the fallow lands into pasture areas by adopting efficient methods of growing herbage and controlled system of grazing?

The backbone of Indian Agriculture is the cattle, as bullock power is the whole and sole motive power used for every agricultural operation in India. Any system of cropping which is likely to come into conflict with the interests of the cattle population must therefore be scrupulously avoided. The development of the livestock industry has recently received a remarkable impetus due to the keen interest taken by Lord Linlithgow as Viceroy of India in problems connected with the improvement of cattle. Serious attempts are being made to effect an all round improvement in the cattle of the country by introducing better methods of breeding and as a corollary to this effort, improvement in the feeding of the cattle must inevitably occupy a prominent position as it is generally recognised that improved breeding must always be accompanied by adequate feeding.

It is a well-known fact that the consumption of milk per capita per day in India is far below the minimum quantity prescribed for a balanced ration and the recent second edition of the report on the marketing of milk in India shows that the position to-day is even more distressing as the consumption of milk per head during recent years has further dropped

by about 12 per cent. Apart from the importance of cattle as a source of motive power in Indian Agriculture, the paramount importance of milk in the dietary of human beings cannot be overemphasised and any attempts calculated to improve the health of cattle by providing proper nutrition will therefore not only improve the general condition of the cattle, but in addition would render the greatest service to the population of India—whose daily diet is not only subnormal but ill-balanced—by augmenting the supply of milk.

Since the existing supplies of fodder and the area under pastures are inadequate and since it is not possible to check the practice of maintaining a large number of inefficient cattle which consume fodder which is essential for the better cattle, systems of cropping which are likely to increase the competition between the cultivators and their cattle must be adopted with very great caution and after a full consideration of the pros and cons of this important question. Fortunately for us, if better methods of cultivation and manuring are adopted, it is possible as has been shown before to increase the production of food crops by 25 to 33 per cent so as to adequately meet the food requirements of the population of the country, and it may not therefore be absolutely necessary to bring large areas of fallow land under the plough.

Storage facilities.—In certain cases like wheat, the damage due to weevil attack has been placed at 33 per cent, but taking the modest figure of loss for all crops at 2½ per cent,[18] nearly 1·3 million tons of the stored grain is annually being damaged in India as a result of insect attack. In addition to the various factors relating to the production of crops referred to above, the question of provision of adequate storage facilities to protect the produce against the attack of insects, rats and spoilage due to weather conditions must not therefore be ignored.

MAXIMUM versus ECONOMIC CROP PRODUCTION

In order to receive maximum out-turn of food crops as against the so-called commercial or cash crops, the State must however come forward to help the cultivators whenever required. If we only look to the economic aspects of crop production, as has been always done in the past, the persons to be benefited by this policy are mostly big land-holders, merchants and middlemen who are able to export the produce at profitable rates and meet their requirements by purchasing either indigenous or imported raw and processed foodstuffs at such rates which the average cultivators and labourers cannot possibly afford to pay. In view of the fact that it is obligatory on the part of the State to ensure minimum requirements in respect of food and clothing for every individual citizen, there is therefore no reason why a portion of the increasing industrial and commercial income which is ultimately derived largely as a result of the produce of the land should not be utilised in giving relief in the form of subsidies to the cultivators, should the business of crop production *vis-a-vis* industrial manufacture of finished articles becomes uneconomic or unremunerative. Our soils which have reached a stable minimum fertility level, are capable of yielding increased out-turns to the extent of 25 to 33 per cent, if properly manured and cultivated, and what is wanted therefore is a definite incentive to the cultivators to make the business of production of food crops, if not remunerative, at least not unprofitable. As the average calorific value of the daily diet per head in the case of factory workers and agricultural labourers is only 2,100 as against the minimum requirement of 2,600, production of sufficient food in the country

will not only improve the efficiency of crop production but also industrial manufacture by increasing the efficiency of labour. In this connection it will not be out of place to quote the examples of stabilisation of sugar production from sugarcane and beet in India and England respectively. Had the production of sugar not been subsidised or protected by adequate tariff by the State for a period of 15 years or more, the position of India and England to-day in respect of supplies of sugar would have been disastrous.

Long-range Problems Relating to Food Production

In order to stabilise the production of various crops in general and food crops in particular, it is essential to consider the long-range problems and prepare a co-ordinated plan so as to make India a self-sufficient unit. In this connection it may be mentioned that some of the suggestions referred to above, which though can be put into effect immediately have also an important bearing on long-range planning of food production and in addition to those some other important long-range problems are briefly referred to below.

Experiments to determine maximum crop yields.—Properly planned experiments should be started to determine the maximum crop-yielding capacities of soils, *e.g.*, under a given set of soil and climatic conditions, and by adequate soil management and with maximum applications of manures and fertilisers, what is the maximum crop-yield possible in a given region or locality? An experiment recently conducted with sugarcane has shown that under conditions obtaining in India, yields as high as 100 tons of cane per acre—as against 15 to 25 tons to-day—can be obtained by adopting suitable methods of soil management and adequate manuring and irrigation. Experiments should, therefore, be conducted to obtain similar information in respect of other crops which would give a clue to the dominant factor or factors which affect crop yields. In designing these experiments particular attention should be paid to the organic matter and nitrogen status of the soils, and the standard experiments finally fixed should be simultaneously conducted for a certain specified period at various places under different sets of soil and climatic conditions.

Need for training a large number of young persons.—The need for fundamental research and continuity of research in agricultural science with particular reference to the day-to-day problems of the cultivators that are bound to arise in connection with the work of extension of improved methods through propaganda cannot be underestimated. Research work in agriculture to-day is as important as in any other subject. In order, therefore, to make a band of efficient workers available for both research and propaganda work,[20] steps should be taken to select and train right type of promising young men of all ranks who can sympathetically appreciate the difficulties, requirements and aspirations of the cultivators.

Colonisation of new areas.—Thousands of men who have been recruited to the various branches of the Army Department can be utilised directly or indirectly for agricultural work after the war as follows:—

The demobilized personnel can either colonize certain selected areas and carry out individual or co-operative farming. Services of suitable men can be utilised in organised campaigns against diseases and pests of crops involving the use of elaborate and specialised types of machinery, insecticides and fungicides.

Their services can also be utilised in several ways in the village-uplift work, e.g., (1) running of day and night schools, (2) treatment of simple

ailments of the cultivators and their cattle, (3) running small-scale workshops for repairing agricultural implements, (4) improvement of village sanitation and (5) co-operative marketing of agricultural produce and of commodities required by the cultivators.

Similarly a large number of motor vehicles and tanks can after the war be suitably altered so as to make them fit for power work on the farms. This would not only ensure efficient cultivation of the existing cultivated areas but would facilitate the work of eradicating obnoxious weeds like *kans* (*Saccharum spontaneum*), bunding operations, stopping of erosion and breaking new land, all these factors being vitally important in securing maximum crop yields.

Prevention of fragmentation of holdings.—The problems arising out of the existing laws of inheritance which make fragmentation of holdings possible to such an extent as to make them uneconomic must be examined and adequate steps must be taken to prevent this practice. A suitable system of land tenure which will ensure a long-term and sustained interest to the cultivators who take lands on lease must be evolved. These two factors are vitally connected with the question of maximum yields that can be obtained from the cultivated soil and must therefore be carefully considered and a satisfactory solution evolved.

Stabilisation of Incomes of Agricultural Labourers and Cultivators

A suitable system should be evolved by which basic wages could be assured to the agricultural labourers as is at present being done in the case of industrial workers by fixing their basic wages with the help of the index number of living and granting increased wages in proportion to the increased cost of living. As suggested above where necessary, incomes of the cultivators may also be subsidised to make the business of production of food crops, if not remunerative, at least not unprofitable.

Conclusion

To conclude, problems connected with the present and future food production in India have been broadly surveyed. It has been urged that we must harness together all the forces at our disposal in order to increase the production of food in India, not only to meet her present requirements but to banish the problem of food deficiency for all times to come. The economic factor in the production of food crops must not deter us from the task of ensuring minimum requirements of food and clothing for India's teeming millions. As one of my predecessors has said, "Increased production will help to banish famine and poverty from the land, and to bring us near the realisation of our hope, namely, to make India a garden, ringing with cheerful and contented life, with smiling fields and food in plenty."

The importance and urgency of this subject and the fact that economic and other factors must always occupy a subordinate place in relation to the question of sufficient food production cannot be better emphasised than by quoting the following passage from the speech delivered by President Roosevelt to the delegates of the United Nations Conference on food and agriculture[12] "A sound world agricultural programme will depend upon world political security while that security will in turn be greatly strengthened if each country can be assured of the food it needs. Freedom from want and freedom from fear go hand in hand." It is needless to say that in so far as India is concerned, her food requirements can be best assured by increasing her food production capacity to the desired extent.

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SECTION OF PHYSIOLOGY

President :—S. N. MATHUR, M.B.B.S., Ph.D.

HARMONY AND RHYTHM IN NATURE

(Delivered on Jan. 5, 1944)

I thank you for the trust that you have shown in me by electing me to shoulder the responsibility of this year's Presidentship of the Section of Physiology of the Indian Science Congress.

As a teacher of physiology it has been my aim to impress upon the students that when they learn about some facts regarding a particular organ or system in physiology, they should keep the whole body in perspective and try to harmonize the facts they are learning with the rest of the body as a whole. Whatever changes take place in one organ, they so affect the rest of the body that they are not just balanced for their own sake, but serve some fundamental necessity of the body, either, towards its better working under ordinary conditions, or towards its self preservation under emergencies, when peace time working of the body, so to say, is sacrificed to tide over the crisis. While the activities of the body are being harmonized with one another as a matter of necessity, the very working of the living body demands that, in order that it may continue to be active, there should be alternate periods of rest and work, so absolutely interdependent on each other that they may be compared to the two faces of a picture. This harmony and the alternate phenomenon of rest and work, in a sort of rhythmic manner, seem to be the most fundamental facts of life, to which I have been led while harmonizing some of the apparently different subjects on which I have worked. The résumé of this is now given.

CARBON DIOXIDE IN THE SCHEME OF LIFE

In spite of its being a reputed protoplasmic poison, we remain literally saturated with CO_2, since every cell necessarily produces it by the very virtue of its being alive, because carbon is the main fuel of life. It follows, therefore, that the more life a cell possesses, the more is the amount of CO_2 which it has to produce, and therefore to tolerate. These cells out of the sheer necessity of setting the machinery for the excretion of CO_2 have so habituated themselves that their very life and activity is conditioned by the presence of CO_2. Thus, although, it has been looked upon with suspicion, and for good reasons, its importance to the body could be gathered, e.g., by practising forced ventilation on oneself just for few a minutes, which even then only partially reduces its normal tension in the body.

However, as its poisonous nature, and it alone, was known to the ancients, we do not find any mention of its normal role in the body in the earlier literature. On the other hand, we find ample evidence of the interest shown as to what would happen if it were not normally got rid

of from the body, or when it was actually taken in ; and naturally enough, as the beating of the heart has, from time immemorial, been taken to be the *sine qua non* of life, the heart was the first organ to receive attention of the ancient scientists. It was known to the ancients that the animal, which had been exposed to the influence of CO_2 and was seemingly dead, could be brought back to life by bringing it back to fresh air.

However, experiments directed specifically to the effects of CO_2 on the circulatory system may be said to have been first carried out by Traube (1862-63), who showed that mixtures of CO_2, containing as much as from 20 to 75 per cent CO_2 could be breathed for a few moments, and that they had a material effect on the circulatory system, which he showed later were due to the stimulation of the 'musculomotor system'. Thiry (1864), in view of Traube's work, came to the conclusion that the rise in the blood pressure was due to the constriction of the peripheral arterioles. This was later confirmed by Traube (1865), who concluded that CO_2 was the natural excitant of the vaso-motor-centre. In more recent years Dale and Evans (1922) have shown by doing reverse experiments of over-ventilation that there is a fall of blood pressure due to the lessening of the CO_2 tension responsible for maintaining the tone of the vaso-constrictor-centre. Vincent and Thompson (1928), doubted the results obtained by Dale and Evans and explained that they were due to the mechanical causes consequent on specific operative measures adopted, rather than due to over-ventilation. McDowall (1930), however, after excluding the mechanical causes showed that the fall of blood pressure, if it does occur at all, which sometimes does not occur, was a genuine physiological phenomenon.

As it is well known that the blood pressure depends on two factors,—the peripheral resistance and the cardiac output,—it was not then known which of the two factors played a more important role. I, while doing experiments on the cardiac output, under various conditions, found that CO_2 has a profound effect on the various phases of its beat. In over-ventilation experiments, it was found that with the onset of over-ventilation there is a gradual decrease in the relaxation of the heart, which in its turn decreases the contraction resulting in a gradual, but marked, decrease in the cardiac output. It is, in fact, this factor which is far more responsible for the fall of blood pressure than any peripheral dilatation depending on the loss of tone of the vaso-constrictor-centre due to the washing away of CO_2. In fact, the peripheral vessels may both be dilating on account of the central action, chiefly acting on the arterioles, and constricting on account of the local washing away of CO_2, chiefly acting on the capillaries. Thus, while the combined peripheral resistance may either increase or decrease, the fall in cardiac output is a constant phenomenon.

As a corollary to the results shown above were noted the effects of the increased tension of CO_2 on the heart. It was already known that there was an increase in the cardiac output after the administration of CO_2. The increase in the cardiac output was, however, known to be dependent on an increase in the venous pressure, as had already been shown by various authors. I, however, found that in the beginning of the administration of CO_2, the increased dilatation of the heart resulting in the increased cardiac output was independent of the rise in the venous pressure, which, in fact, fell in the beginning rather than rose, showing thereby that CO_2 actually actively increases the dilatation of the heart resulting in increased cardiac output. It was thus established that a certain tension of CO_2 is directly

necessary for the diastole of the heart and indirectly for the systole which depends on the diastole and thus for its entire activity.

Carbon dioxide had long since been known to be, *par excellence*, the respiratory stimulus, or rather, in our modern and more correct conception of a rhythmic respiratory centre, we shall say a necessity to maintain and regulate its rhythmic discharges. It became now evident that it has a profound influence not only over the activities of the respiratory but circulatory system as well. A slight lowering of its normal tension brings both the systems to a standstill, respiratory first and only a moment later the circulatory, here acting chiefly on the heart.

Pericardium and its Importance

The limit of the heart's dilatation is provided by the pericardium. The increased cardiac output noticed, both after the administration of carbon dioxide and the production of mild asphyxia, depends upon the previous states of the heart. Under anaesthesia, generally, there was found to be a gradual accumulation of carbon dioxide with progressively decreasing oxygenation of the blood. This condition of the animal leads it to its gradual death resulting from the increasing hypodynamic condition of the heart, till its output decreases to the extreme.

In my experiments the increase in cardiac output after the administration of carbon dioxide showed lesser response as the observations were repeated, till towards the end of the day it vanished altogether and even was replaced by a decrease. There is a possibility that those workers who found that asphyxia and carbon dioxide reduced the output of the heart were dealing with a hypodynamic heart, *i.e.*, a heart in its extremely dilated condition, when it is actually striking against its parietal pericardium.

When the heart has to increase its output, two things must be fulfilled, it must expand more and also be sufficiently fresh and healthy to contract better, after that. A hypodynamic heart striking against the pericardium cannot perform these acts and ultimately stops. If, however, pericardium were not there, the heart would stretch to such an extent that an irrepairable harm would be done to its muscles and other tissues. Before that is allowed to occur if the pericardium is slit and there is room for the heart to dilate, it does so at once and the beats are revived. Further it has been possible in a few animals, with careful artificial respiration, to reduce the dilatation of the heart and put it back into the pericardium and stich it up. (It is suggested that in desperate conditions when such a condition of the heart is suspected expert surgeons might take advantage of this).

Action of CO_2 on the Heart of Ciona-Intestinalis

Carbon dioxide being universally present, what is true of its action on the hearts of higher warm-blooded animals, ought also to be true for the hearts of the lowly cold-blooded animals. At least in one such animal I myself had the opportunity of testing this truth. At Plymouth Marine Biological Laboratory I was engaged in studying the reversal of the heart cycle in the Ciona-Intestinalis. These animals did not survive for long in the aquarium tanks with the result that when they were brought to the laboratory, a fair number were found to be already 'dead'. (The experimental advantage with these animals is that after taking out their 'tunic' in which these animals are enclosed, one can see the whole interior, because their bodies are transparent). By examining their hearts

carefully it was suspected that the 'dead' hearts were a shade smaller than the living hearts of nearly the same sized animals. The pH of the sea water in the tank was possibly slightly higher than was suitable for these animals, as by bringing down the pH, by blowing into the water in the dish the hearts of these 'dead' animals were revived. Afterwards these animals, even though roughly handled and mutilated, could be kept alive in this manner for over twenty-four hours. From these experiments it was possible to conclude that the normal tension of carbon dioxide necessary for the well-being of these animals was not present in the tank water in which they were kept, with the result that the diastole gradually decreased till the hearts did not dilate at all and stopped in systole.

Besides its direct action over the vital circulatory and respiratory systems, carbon dioxide still, though in an indirect manner, has to play a role not less important. This it does by taking charge, so to say, of the regulation of the H-ion concentration of the blood, whenever a change in the H-ion concentration of the blood or other fluids takes place.

Hydrogen-ion Concentration of Saliva

Before these studies were undertaken it was sometime during 1925-1926 the reaction of saliva was usually stated to be alkaline, i.e., above pH 7. Later on it was stated to be neutral or even slightly acidic in reaction. I, on the conclusion of my studies had found it to be both alkaline and acidic, regularly passing from one reaction to the other through the neutral point ; *and that this regularity was associated with the meals.* I did not start all at once with the study of its reactions, but I was led to it from the studies on the digestibilities of different rice and allied preparations. In these later studies I found that parched rice was the more easily digested. Later on I also found that parched rice was not only more easily digested but that it was richer in vitamin B than ordinary bazar rice (not par-boiled). During the course of these studies, which were made on medical students and departmental servants and myself, I found that although the majority relished the parched rice, there were a few who had no liking for it. Those who liked it poured out a large amount of saliva and those who did not, could not pour out enough saliva even to moisten and swallow it. With this incident, which led me to think that on liking, may also depend the intensity of salivary digestion, I started the test tube experiments of testing the intensity of the saliva of different persons. During the course of these studies I tested the reactions of saliva as a routine measure and found that they varied not only in different individuals, when tested simultaneously, but differed even in the same individual when tested on separate occasions. The important thing that I discovered was that those who liked a particular food, and also either felt appetite or were hungry, poured out a large amount of saliva which had a strong alkaline reaction, and, on the other hand, those who did not, poured out only a small amount of saliva which had either a neutral reaction or even a slightly acidic one. This led me to test the reactions of saliva in the same individual who might have either acidic or alkaline saliva during the course of the same day. It then occured to me that the reaction might regularly vary with the meals. I did the experiments on myself first, daily for a number of months, and confirmed them later by doing mass experiments on the students and came to the following conclusions:—

(1) There are regular changes in H-ion concentration of saliva with the meals, e.g., in persons who are hungry and also feel appetite for a particular food the reaction of the saliva becomes strongly alkaline

synchronising with the time of their being either hungry or feeling the appetite ; if this is followed by the food, particularly by the food of their choice, the reaction continues to be alkaline during meals and that the alkalinity persists for a few minutes even after meals. Then the saliva quickly gets less and less alkaline till it actually becomes slightly acidic ; it then further changes to alkaline reaction, but now at a slower rate and further that it does not reach the same intensity of the alkaline reaction as it was in the beginning. Saliva now remains alkaline for some time, the time depending on the nature of the food, and becomes slightly acidic after two or three hours, to turn again slowly into alkaline reaction till the peak of alkalinity is reached at the next meal time, provided the person is again hungry or feels appetite. During these studies it was also discovered that the amount of the saliva ran parallel to its pH, that is, it was in direct proportion to its alkalinity.

(2) The regular changes in the H-ion concentration of the saliva described above are reflected in the urine, i.e., the reaction of the urine is of the same nature as that of the saliva, (the precaution to be observed at this moment is that the reaction tested should be of the urine passed at that very time, that is, the reactions are tested of the synchronous samples of both urine and saliva).

(3) Changes in the H-ion concentration of the saliva occurring during meals, as described above, are reflected in the alveolar CO_2 tension of the lungs, which is appreciably increased to maintain the pH of the blood.

(4) Changes in H-ion concentration of the saliva run parallel to the changes in the H-ion concentration of the gastric juice, but, of course, of opposite order. The latter, can thus be indirectly studied through the pH of saliva.

From the above it can be concluded that the reaction of saliva can be a faithful guide to the reaction of the blood at any time. As a point of practical importance it is very strongly suggested that the testing of the reactions of saliva may be substituted for the test meals and analysis of the gastric juice. The advantages of this study will not only be on account of its very great simplicity, but that it can be studied under absolutely natural conditions without resorting to any operative measures and unnatural test meals. These test meals and similar measures, *e.g.*, watching through the stomach windows, as was done in the case of the classical experiment by Boeumont upon Alexis St. Martin, have led us to at least one very erroneous conclusion, that appetite juice, in human beings plays an unimportant role. An exact reverse, however, is the fact. If appetite juices play any role in the digestion, and I assert that they do, then their most important role must be in human beings.

Role of Chewing in Digestion

Related to the above is the role of chewing in digestion. Besides helping the digestion in the manner already known, I have found that it increases the pH and the amount of saliva depicting the parallel changes, but of pH in opposite direction, taking place in the stomach. Thus we can say that chewing does not only help in breaking the food into fine particles but is a help both in the increased production of the saliva and consequently also of the gastric juice.

In this connection I have found that the pH of saliva also increases during defaecation. This probably is due to a setting up of a reflex which on the analogy of the gastro-colic-reflex may be termed as colon-gastric-

reflex. By calling it colon-gastric-reflex, I presume that salivary reaction is secondary to increased secretion of gastric juice at that time. In any case it can at least be safely assumed that the digestive system is better prepared for digestion after emptying the colon rather than when it is loaded, and just as we can take help of the gastro-colic-reflex in relieving the atonic colon of persons suffering from habitual constipation, which is so common, we might also take help of the colon-gastric-reflex in helping the person suffering from atonic dyspepsia.

This interrelationship between the H-ion concentration of saliva and gastric juice found confirmation in another way. If, as it was already known, the H-ion concentration of infant's gastric juice be less than that of the adults then it could be foretold that the pH of their saliva would also be less. This was happily found to be a fact in my experiments with infants' saliva. Further, as I have already stated above that the amount of saliva is in direct proportion to its alkalinity, it is no wonder that the amount of saliva secreted by the infant is much less than in older children and adults. All this is in conformity with the infants' requirements, whose diet consists only of milk which neither requires salivary enzymes for its digestion nor the strong acid in the gastric juice, for the digestion of the milk is better carried on by a weaker gastric juice.

The characteristic physiology of cells, tissues, organs, and organisms that we know today is the outcome of evolution and adaptation to the environment which has been going on for untold millions of years. It is probable that when life started on this earth the atmosphere contained far greater amount of CO_2 and far less oxygen than it now contains. It can be presumed, therefore, that animal life adapted itself to the unavoidable presence of CO_2, both inside and outside. This adaptation to CO_2 which has been going on for millions of ages has been so perfected today, and the machinery responsible for this perfection, is so constituted that the slightest change at one place is balanced by the opposite change at the other. This perfection of the maintenance of a certain standard of CO_2 tension in the body is amply illustrated by the simultaneous changes of the opposite nature taking place in the reactions of the secretions of the mouth and the stomach which are further helped by changes taking place simultaneously in the body elsewhere, e.g., in the changes taking place in the CO_2 tension in the alveolar air and the reaction of the urine. It is significant to note that these changes of CO_2 tension in the body fluids and the resulting changes in the H-ion concentration are not just taking place for the sake of keeping the H-ion concentration constant in the internal fluids, but that the very existence of the individual is inextricably bound with them, as if the whole nature is contriving to one common end. Thus we see that when one secretes a large amount of saliva, it is not only secreted just to balance the H-ion concentration on account of the simultaneous secretion of the appetite juice in the stomach, but it is actually needed for the better chewing, swallowing and digesting the food that is to follow. It was at one time believed that the salivary digestion plays practically no role in the digestion of the food, for the reason that the food does not stay in the mouth and that the salivary digestion will stop as soon as it is mingled with the acid of the gastric juice. Now it is well known that salivary digestion does continue in the stomach and for a pretty long time, the reason given being that the thorough mixing of the food with the acid gastric juice takes some time. It is not, however, still realized that had the nature contrived for the stay of the food in the mouth without, however, any

other change in the rest of the nature, salivary digestion would not have taken place at all, because it is now known that the salivary digestion of starches, takes place best at the neutral or even at the slightly acidic reaction. As I have already shown the reaction of the saliva is strongest towards the alkaline side during chewing, this reaction is not so well suited for the digestion of the starches as when it will be made less alkaline on mixing with the acid gastric juice. One might think that the secretion of the alkaline saliva is secondary to the primary secretion of the acid appetite juice in the stomach, but the fact that chewing at any odd time —which must necessarily be accompanied by the secretion of the saliva, —is also accompanied by a simultaneous secretion of the gastric juice, may be taken as demonstrating that the secretion of saliva is primary and that of the stomach secondary. We, however, are not so much concerned in finding out which is which—probably the two acts are simultaneous—as to the fact that both the secretions are necessary for the proper digestion of the starches, while at the same time the alkaline saliva preserves the teeth, specially important during chewing, and that the acid gastric juice, besides neutralising the saliva, is needed for other equally important works. These secretions of opposite reactions also casually help to maintain the H-ion of the blood at a fixed level which is required for other activities of the body. Should we not marvel at the economy and harmony of nature which is evolving the starches and the digestive machinery and its working in the animals on parallel lines as if the whole nature is interwoven in one net?

As I have already mentioned that CO_2 is a sort of necessary and unavoidable 'evil', which has so inextricably worked itself into the whole of nature's machinery, it is unthinkable what would have been the face of nature had this evil not been present. It is not just only in the animal body that the balance of CO_2 is so delicately maintained that in spite of the frequent disturbances occurring in its contents in the body the balance is struck even without our awareness, but the same is true for the whole nature, for it is said, "Though CO_2 occurs only in small quantities in air it plays quite an important part . . . . in the due . . . . performance of the respiratory functions of animals and the digestive functions of the plants ; a little deficiency or excess would severely affect all these, and it is produced in such large quantities in volcanoes and coal fires, and is consumed in such large quantities by plants and rocks that considerable variations in its total volume might very well take place. Such variations are, however, automatically checked by the sea ; for, as the pressure of CO_2 in the air rises, more enters into solutions in the sea ; and as it falls, some of it in solution in the sea returns to the air. How effective this regulation is the following will show. At present there are three volumes of CO_2 in ten thousand of air. In order to increase the proportion to four in ten thousand it would be necessary to more than double the amount originally present, for sea would absorb much the greater part added." It may aptly be said that just as blood of an individual acts as an efficient buffer against its increase or decrease, the sea acts similarly for the whole earth. If, however, CO_2 is artificially increased or decreased the machinery which was habituated to work within a certain tension is brought to a standstill. Even if it were present permanently in only slightly different proportion, the whole vital aspect of nature would change. It is marvellous that this gas should be found in apparently the exact quantity needed for the working of the whole of nature. Is it not an astonishing example of perfect harmony in entire nature?

Carbon dioxide and Temperature

From what has already been described, it is evident that a certain tension of carbon dioxide is essential for the normal working of the heart, which on either side of it alters its activities from the just appreciable to the extreme measure, i.e., it may stop its activities altogether and remain either in the extremely dilated or contracted state, depending on whether the tension of carbon dioxide is increased or decreased respectively. But this working range of carbon dioxide tension is conditioned by temperature.

The temperature of my experimental animals, mainly cats, was raised by artificial means. In the beginning, for some time, the internal temperature of the body does not rise, as the tendency to rise is counterbalanced by the increased number of respirations. The balance, however, is soon lost and the internal temperature gradually rises. After staying for some time, it then rises more quickly till the animal dies. With the quick rise of temperature there is a further increase in the number of respirations when a marked decrease in the depth is noted, or, in other words, the respirations become very quick and shallow. Heart simultaneously increases its number of beats, and in the beginning there is also a small and temporary rise of blood pressure, which, soon after, as the temperature continues rising, starts falling, the fall being abrupt towards the end. This fall in blood pressure is found to be mainly due to the decrease in the cardiac output. The important point to be noted is that the slowing of the heart does not take place at any stage and, in spite of the very marked increase in the number of beats, increase in the cardiac output which occurs in the beginning is of a much shorter duration than what is noted during the administration of CO_2, when, on the other hand, slowing and increased cardiac output is a marked feature.

The study of carbon dioxide tensions in these temperature experiments reveals an interesting feature. While at an ordinary room temperature artificial over-ventilation produces apnoea much more quickly, and with a smaller decrease in CO_2 tension, it remains ineffective when the temperature of the animal is very high, although the CO_2 tension even without doing artificial over-ventilation has already become less than is compatible with the ordinary respiratory activities at room temperature. In other words, respiratory centre at higher temperature is tuned, so to say, to work at a lower CO_2 tension than is possible at an ordinary temperature. An important point to be noted is that, whereas it is much easier to revive the animals when they are dying with the effects of excess of CO_2, or asphyxia, by ordinary artificial respiration, or in the extreme cases with the administration of oxygen, it is almost impossible to revive the animals dying on account of the effects of heat, unless, with the lowering of the temperature, which is the first preliminary, CO_2 is also administered along with the oxygen. The reason, as already pointed out, appears to be that during the rise of temperature the respiratory centre got itself tuned to work at a lower CO_2 tension than that at which it is accustomed to work at ordinary temperature. Thus when we lower the temperature, but do not at the same time take measures to increase the CO_2 tension, the vital centres, chiefly the respiratory and cardiac, fail to work at the lower CO_2 tension, now when the temperature is less. The animals were more quickly and permanently revived when along with the administration of oxygen, CO_2 from 5 to 10 per cent was also added. Though no human experiments have been done, but it is suggested that the heat and sun-stroke patients, when their vital centres may be failing, should be given oxygen and CO_2 mixtures to

breathe along with the measures that may be taken to lower their temperature.

The relationship that exists between the carbon dioxide and the increased temperature holds true also in the case of lowered temperatures, but, of course, of the reverse nature, that is, with the decrease in the temperature there is a gradual but marked decrease in the respirations and the beating of the heart ; although in these conditions it is found that CO_2 tension has, in fact, increased to such an extent that at ordinary room temperature there would have been a tremendous increase in both the respiratory and the cardiac activities. This appears to be one of nature's chief mechanisms, to conserve the heat of the body.

Thus though apparently CO_2 is such a great necessity that its presence is absolutely necessary for the life of both animals and plants, it still at its best takes the second place when we compare it with a still bigger necessity, the maintenance and the regulation of the internal normal temperature, at least in the case of the later evolved warm-blooded animals. As the protoplasm can work only within a certain limited range of temperature, the warm-blooded animals have evolved a mechinery to maintain and regulate that temperature in order that they may emancipate themselves from the vicissitudes of their environments. It is clear, therefore, that body sacrifices a portion of its coveted possession, the carbon dioxide tension, in order that it may tide over an emergency, which would otherwise kill it. The necessity of the maintenance of a certain carbon dioxide tension has therefore taken a second place.

Need of Constant Supply of Oxygen

Could there be a still bigger necessity which would throw in its turn the temperature in the background? Yes, there is one at least and that is the necessity of a constant supply of oxygen. During the course of low temperature experiments, when both the respiration and the circulation were at their lowest ebb I observed that if at that time some anoxic condition was produced, say by cutting off the oxygen supply, at once both the respiration and the circulation were flared up, so to say. Evidently the regulation of the temperature has been thrown into the background in face of this still bigger necessity, the constant supply of oxygen.

In nature these two conditions, that is, a very low temperature and a very low tension of oxygen are simultaneously present over high mountains and high altitudes in aeroplane ascents. It is suggested that while measures are taken to combat the anoxic condition, the importance of temperature, and CO_2 tension, should not be lost sight of.

Significance of the 'Vagus' Nerve

While the necessity of CO_2, temperature, and oxygen is realized in increasing importance for the life of the cells, organs, or individuals, it should not be lost sight of that the greatest fundamental necessity of life is the alternate rest and activity. With life the idea of movement and work, depending on these two alternating phases of rest and activity, is implied. This implication would be made clearer by my résumé of the work done on the significance of the vagus nerve.

Weber brothers (1845) first described the action of the vagus nerve on the heart. They showed that if their peripheral ends were stimulated,

there was a marked slowing of the heart or the heart stopped beating altogether. This fact can even now be demonstrated.

Experiments of this nature are responsible for passages like this, "The vagus exerts a continuous restraining action on the rate of the heart (tonic inhibitory action). This is proved by the acceleration which follows section of these nerves in most animals, or "paralysis" of the nerve endings by atropine in man. The degree of vagal activity, or vagal tone as it is called, is the chief factor controlling the rate of the human heart at rest. Stimulation of the peripheral end of the cut vagus proves that the nerve can depress every part of the cardiac mechanism." Before describing what I consider to be the action of the vagus nerve, it would be apt to quote a passage from Burridge's book, "Excitability, a Cardiac Study". "The vagus is compared with a rein to hold the heart in check, and the sympathetic with a whip stimulating the heart to increased activity. In many animals, however, not excluding ourselves, it has been found that both these nerves exercise a tonic activity, a condition of affairs making the whip, and rein simile somewhat awkward. None, for example, would keep in his employment a coachman who was perpetually flogging his horses and yet always holding them in; nor is it likely that employment would be found by a chauffeur who always kept the brakes of the car partly on and compensated this through using a wider throttle. Yet, such are the parallels to combined tonic activity of both vagus and sympathetic so long as you consider the one a depressor and the other a stimulant. Evidently there must be something wrong somewhere unless you are prepared to suggest that Nature is essentially a bad worker, a suggestion having such an inherent improbability that one begins to look round for some other explanation of the significance of double nerve supplies to organs".

It has been known for a long time that asphyxia and administration of CO_2 caused a slowing of the heart (Verworn Jerusalem, Starling, Doi, Gilbert, Greene, Hopping, Schneider and Trusdell). McDowall has shown that in the course of the same asphyxia both acceleration and slowing occur, acceleration occuring first and slowing afterwards. Hill and Flack noted slowing of the heart during asphyxia and administration of CO_2; as they simultaneously noted the fall in blood pressure, they attributed both of them to heart failure. Gollwitzer-Meier found that during the administration of CO_2 the minute volume of the heart decreased. This he explained as due to a reflex from the lungs carried by the vagi to cardio-inhibitory-centre, causing slowing of the heart and thereby decreasing the minute volume.

During the course of my studies I found similar decrease in the cardiac output, but always towards the end of the day, that is to say, five or six hours after the animal came under anaesthesia or in other words in a stale heart. But, should that be the case with fresh and vigorous hearts? Slow pulse rate is generally considered to be a sign of efficiency. Henderson and co-workers have showed that athletes have got a slow pulse rate. McDowall has shown that anoxaemia causes, as an after-effect, an increase in the excitability of the vagus centre. He has suggested that the slow pulse in the athletes, which is the result of prolonged training and exercise, results from the same cause, i.e., a state of slight anoxaemia during the exercise. He is of the opinion that the function of the vagus is related to the adaptation of the heart to the requirements of exercise. In view of these observations it should come rather as a surprise, if the slowing of the heart, of course moderate, should by itself cause a decrease in its output.

My results have been according to the expectations. Both asphyxia and administration of CO_2 after a stage of short acceleration cause a marked slowing of the heart and this slowing is associated with not only no decrease in minute volume, but, a definite increase, which may even be greater, and more often it is, than the increase noted during the acceleration which precedes it. If, however, the experiment is continued, ultimately heart block is produced and the heart fails. These results have been obtained with the cardiometer. In the absence of cardiometer experiments, which previous workers did not do, it is quite natural that the fall in blood pressure should be attributed to the fall in cardiac output, e.g., when on the blood pressure tracings we find a fall in blood pressure, associated at the same time with slowing of the heart, it is only obvious that the blame should fall on the heart producing decrease in the minute volume ; on the other hand, where there was no fall in blood pressure and still the slowing was noted it was assumed to be a case of balanced action between the vasomotor and cardio-inhibitory mechanism. In my experiments the fall was shown to be due to a much greater decrease in peripheral resistance, as actually registered by a limb plethysmograph simultaneously with the heart cardiometer which registered an increase in the output. It is obvious that the slowing of the heart will increase the diastole and will give the heart more time to fill, dilate and conserve energy, which according to Satrling's, 'law of the heart' will give a bigger stroke volume. Thus we have a balance between the slowing in the number of beats and the increase in the stroke volume. It is the stroke volume that generally predominates, provided, the heart is in good condition and is capable of accommodating the larger quantity of the blood following into it on account of the increased diastolic period. It is obvious, therefore, that the slowing of the heart is a protective mechanism for the conservation of the energy which may be utilised in times of emergency.

After doing experiments with intact vagi, it became necessary to study the effects of CO_2 and asphyxia on the hearts without vagi. In these hearts it was found that the preliminary acceleration noted in the normal hearts, as stated elsewhere, continued, but with rapid decrease in the amplitude of the individual beats, till there was no amplitude at all, no output, and no blood pressure, and the animal was dead beyond recovery. For all these to happen no more time was required than was found necessary for the production of mild asphyxia in an animal with intact vagi, i.e., between one and two minutes. The result is like that of a spendthrift who has no income and squanders away down to the last pie and becomes a bankrupt.

Without going into the details of the physico-chemical changes which, might be taking place and effecting the two conditions of the heart, i.e., the diastole and the systole, we should think of the one fundamental principle which is applicable to the whole body and to which the heart cannot be an exception. That principle is of rest and activity in its broadest sense or the restoration and the expenditure of energy. Our whole life is one play of these two alternate phenomena so intimately interwoven with each other that the one is absolutely dependent on the other. If, for the present, we leave the voluntary activities out of consideration, all our involuntary activities are under the control of the autonomic nervous system, divisible into adrenergic and cholinergic nerve fibres. (I have purposely avoided using the terms sympathetic and parasympathetic, because they are adulterated with anatomical considerations). Even though the adrenergic and cholinergic activities of the body are inextricably mixed with each other, still it is possible in a very broad sense to

distinguish them apart from each other. Sleep and wakefulness, for example, may be considered to be the two biggest components of our life separately distinguishable from each other, the former presided over by the cholinergic part of the autonomic nervous system and the other by its adrenergic component. The constriction of the pupil, the retraction of the eyeball, closing of the eyelids, slowing of the heart beat, undisturbed continuance of the digestive activities, greater tendency for sweating (personal observation), etc., and the actual production of sleep-like condition by the injection of acetyl-choline into the ventricles of the brain are incontrovertible evidences that sleep is the restful component of this rhythm of life. On the other hand, less constricted pupil, prominent and open eyes, less slow heart, more disturbances in digestive activities, tendency for lesser sweating under similar conditions and the tendency for all these states to get exaggerated during any activity and emergency or the simulation of these conditions by the injection of adrenaline not only point to the fact, that the wakefulness is the other component of this rhythm of life, but is also an indirect confirmation of the other. Vagus nerve of the heart belongs to the cholinergic group of fibres and therefore responsible for the restful component of this rhythm--here we can substitute the heart for the whole body. After oxygen, sleep is considered to be the greatest necessity of life, so much so that it comes before water, in other words, life is an impossibility without sleep, and naturally enough because we cannot think of any rhythm without its two components. Therefore, if we say that vagus, one of the cholinergic nerves, or rather the chief cholinergic nerve of the body, presides over the diastole of the heart, we are on firmer ground if we say that it is the inhibitory nerve of the heart.

Rhythm in Nature

During the course of studies on the effects of carbon dioxide, etc., on cats, seasonal variations were incidently discovered, when the entire findings of the year were analysed and sorted out. The results were confirmed when similar reactions appeared again in the course of the next year.

It was found that the reactions which required greater para-sympathetic activity were prominent in autumn and winter, while those which depended more on sympathetic activity were present in spring and summer. It is significant to note that autumn and winter on the one hand and spring and summer, on the other, are the months of general rest and activity respectively in the entire animal and vegetable kingdom. This on the analogy of the alternating phenomenon of rest and activity in the heart and similar alternating phenomenon of wakefulness and sleep in the whole individual may be termed as rhythm in nature. This conception finds confirmation in the fact that these alternating phenomena of rest and activity, in all these three instances, are seemingly dependent on the same parasympathetic and sympathetic activity respectively.

The human beings, at least as far as the haemoglobin is concerned, also come in the same scheme of nature's yearly rhythm, because seasonal variations of a similar order have been discovered in their haemoglobin contents.

At one time it was the practice in the Lucknow Medical College to get the students to do the haemoglobin experiments during the months of August and September. In these months the students usually did the experimental work on frogs, as they do even now, and the haemoglobin experiments were put in during the same time in order that the students

may not miss any practical class when frogs perchance were not available. It was noted year after year that the students in general got the lower figures for their haemoglobin than what was supposed to be normal. Their results were checked and found correct and it was concluded at that time that Indians, generally, though apparently healthy, had a lower standard of haemoglobin. After some time it was thought that possibly there might be seasonal variations in the haemoglobin and soon after, on the basis of the studies continued during the winter, it was discovered that there is a regular rise and fall in the percentage of haemoglobin in Indians, and that the curve runs parallel with the curve of the outside temperatures but in the opposite direction. Later on more extensive and more regular studies were undertaken when haemoglobin percentages were studied in the same individuals almost daily throughout the year. It was then discovered that there is another peak which may be termed as the 'spring rise of haemoglobin' in March, April, and May. It could then be concluded that there were genuine seasonal variations in the haemoglobin and that the curve did not slavishly follow outside temperature as had been concluded a few months previously. Our purpose just now is not to discover an explanation for the spring rise of haemoglobin as to point out that human beings, at least in this respect, are in harmony with the entire living nature of both the plants and the animals, i.e., this rise of haemoglobin is in conformity with the generalised activity found in the rest of nature.

Conclusion

I have described briefly some of the fundamental necessities, which must be satisfied before the body can work and maintain a certain standard of physiological activity. One of these preliminaries appears to be the very substance which is being formed as a necessary outcome of their being alive. This carbon dioxide, sets the machinery going in advance as a preparation, so to say, for obtaining the primary necessity of life, *viz.*, oxygen. Although all living cells must need this deliverer of oxygen, its necessity should be felt more by those that are more active, because more they produce it more is the necessity that it should be got rid of, and that in the process proportionately increased amount of oxygen be supplied in. How admirably this is done locally, by the dissociation of oxygen, is so well known. The machinery of the body on which the primary duty of its expulsion falls should, for similar reasons, be still more sensitive in a manner, that while it may be expelled, oxygen may be taken in. That respiratory system takes this duty upon itself, and how efficiently it performs it, we know it for truth. If the heart, without which the entire respiratory machinery would be ineffective, did not respond in a similar manner, it would have rather come as a surprise.

This stimulus, present both in and about every cell in the body, does not just stimulate a machinery for its own expulsion and the simultaneous entry of oxygen ; it does many more acts of equal or rather more fundamental importance. This is done by carbon dioxide by playing the main role of maintaining and regulating the H-ion concentration of the blood and other fluids and indirectly ministering to the digestive needs of the body.

However, so important otherwise, carbon dioxide does not tenaciously hold to its position in the body in the face of a bigger necessity, the regulation of the temperature when it increases ; or, on the contrary, it can hold on still more tenaciously when it falls, in order that more heat may be lost or retained through the opposite tendency of the increase

and the decrease in respiration respectively. Regulation of temperature therefore, is a bigger necessity and must take precedence.

When, however, a still bigger necessity, the need of a constant supply of the necessary amount of oxygen makes its appearance, regulation of temperature also is thrown into the background, *i.e.*, when the temperature is decreased the tendency for the slowing of both respiration and circulation is nullified in the presence of a lowered tension of oxygen. On the other hand, when temperature is raised in the presence of an anoxic condition the increased rate of respiration serves both for temperature and oxygen.

The more primary necessity of the life, however, is the alternate period of rest and activity. The vagus nerve of the heart on this conception is considered not as the inhibitory nerve, but as the nerve which controls and regulates the restful component of the rhythm of the heart and restores the energy lost during contraction.

Speaking for the body as a whole there is a daily rhythm consisting of sleep and wakefulness and a yearly rhythm of alternating periods of comparative rest and activity, both apparently under the guidance of the cholinergic and adrenergic parts of the automatic nervous system. While the daily rhythm is so obvious, human beings seem to pulsate also with the yearly rhythm so manifest in the rest of nature, as evidenced in the increase of their circulating haemoglobin in the season of universal activity, the spring.

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SECTION OF PSYCHOLOGY AND EDUCATIONAL SCIENCE

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THE PRACTICAL ASPECT OF EDUCATIONAL RECONSTRUCTION

(Delivered on Jan. 5, 1944)

1. Is it necessary for the future welfare of (*a*) India herself (*b*) the British Commonwealth of Nations (if India remains a member of it) and (*c*) the World at large, that India should be provided with national system of education and the other social services, which are enjoyed by the so-called civilised countries?

An apology may be needed for beginning this paper with a question which nowadays in any other connection than India would almost certainly be regarded as one to which there could be only one possible answer.

Anyone, however, who knows anything about the present state of education, to say nothing of the other social services, in this country will realise that the question is anything but a rhetorical one. Consequently, there would seem to be no alternative but to treat it seriously and to try to give reasons why the early development of an adequate system of social security is as necessary for India as it is for any other country. What is there about India which makes it undesirable or unnecessary or impracticable that she should set her feet on the path which not merely Western nations but Russia and Turkey and China have deliberately decided to follow?

2. I am, however, by no means anxious that it should be taken for granted that the diffusion of Education on the widest possible basis will automatically guarantee the establishment and maintenance of universal peace and prosperity. The cause of real education has not been helped by the tendency of woolly-minded philanthropists to assume that education with a big E is necessarily a good thing. The totalitarian countries have given us a timely reminder that education can be made as powerful a means of corrupting as of improving the mentality of a nation. Then again, we do not need to search our acquaintance, or even ourselves, to find proof of the saying that a little learning is a dangerous thing. Nor can it be claimed that education always brings happiness; in fact it may well be that its real object is to create that divine discontent which is the most effective stimulus to individual and national regeneration. But at the same time it has always been and presumably always will be a primary instinct of human nature to want to know about things, both to satisfy its innate curiosity and to ensure the preservation of the race by enabling it to assert control over its environment. As life grows more complicated, it is beyond the power of unaided personal experience either to satisfy curiosity or to acquire the requisite control and it is the function of education to pass on accumulated human knowledge in these and other respects as well as to encourage further enquiry. With all respect to Rousseau's noble savage and with a full realisation of the imperfect way

in which education has so far fulfilled the function referred to above, it remains true or at least arguable that through education men and women can be equipped to live fuller, happier and generally better lives than they could possibly do without it. So at any rate those think who have tried it, for is there any free nation which has once been given a public system of education, however imperfect it may be and whatever the opposition to it in the beginning, that would now submit to be deprived of it? If this is true, what justification can there be for denying to Indians of all peoples in the world the satisfaction of a need of which all other nations are becoming increasingly conscious? Moreover, even if we can reject the issues so far raised as mere academic abstractions, we still have to remember that we, the Allied Nations, have pledged ourselves to the ideal of democracy. Democracy, like education, is not *ipso facto* a good thing. Plato from his experience had a poor opinion of it and we know from our own experience that you do not make a man a good citizen simply by conferring a vote on him. It is the sort of democracy, just as it is the sort of education, which matters. But when all is said, it is democracy above all other known forms of human association which embodies the ideal of all for all instead of each for himself and holds out the hope, however remote, of a society in which the many, as distinct from the few, can live the full life. That I suppose is why most of us believe in the idea, however much we may distrust current manifestations of it, and why we see in such instruments as education the means of raising standards to a level which will at last make government of the people by the people for the people a practical proposition.

Meanwhile we have reason to be grateful to the Nazis and Fascists for giving us some hope that through education this ideal is not an unrealisable one. They have shown us what public instruction consistently applied or misapplied can achieve. *Corruptio optimi pessima* ; the very success of the Nazis encourages us to believe that the right type of education, if we can only discover it, is the most potent weapon in our armoury for the betterment of the condition of mankind. There is a further and still more practical consideration. If a little learning in the individual is a dangerous thing, a little learning in a nation is not less dangerous. In fact it becomes cumulatively more so, since it is axiomatic that the intelligence of a mob is below the average intelligence of the people who compose it. An India, 85 per cent of whose population are illiterate and liable, as we have seen more than once in recent years, to be stampeded by political or religious excitement, however irrational, constitutes a field for mischief-makers, the indefinite continuance of which world opinion in search of a more stable future can hardly be expected to tolerate. Is it unreasonable to anticipate that whatever may satisfy Government or big business or all the other vested interests whose vision is either oblique or retrospective, the logic of any post-war settlement will demand a drastic change in the present state of things?

3. What then is the nature of the changes that are called for and what is the minimum programme of development which will place India on an approximate educational level with other countries? Without entering into unnecessary detail I will try to state the essential requirements briefly :—

(*1*) Universal, compulsory and free education for all boys and girls from the age of 5 or 6 until 14, in order to ensure literacy and the minimum preparation for citizenship.

(*2*) A reasonable provision of education before the compulsory age for school attendance in the form of nursery schools and classes. This is

important mainly in the interest of health, particularly in areas where housing conditions are unsatisfactory.

(3) Secondary or high school education for those children who show the capacity for benefiting by it. Probably to satisfy this requirement provision should be made ultimately in high schools of various types for not less than 20 per cent of the boys and girls in each age-group. Variety both in types of school and in the curricula of individual schools is essential to suit the varying tastes and aptitudes of the individual pupils on the one hand and the requirements of their future occupations on the other. In addition, so that no boy or girl of outstanding ability may be debarred by poverty from further education, liberal financial assistance in the form of free places, scholarships and stipends must be forthcoming.

(4) University education, including post-graduate and research facilities for picked students. It is difficult to fix a quantitative standard here but probably when a High School system as contemplated above has been fully established, about one pupil in every 15 should be found fit to proceed to a University.

(5) Technical, commercial and art education. The amount, type and location of this will necessarily be determined to a large extent by the requirements of industry and commerce.

(6) Adult education, both vocational and non-vocational of all kinds and standards, to meet the needs of those who were denied adequate opportunities in their earlier years or recognise the importance of supplementing what they then received.

(7) Arrangements for training the vast army of teachers which a system of this kind will require.

(8) An efficient school medical service, which will see that children are made healthy and kept healthy. This means treatment as well as inspection and the provision of proper nourishment in necessitious cases. It is a waste of time and money to try to teach a child who is underfed or conscious in other ways of serious physical discomfort. Health also postulates the provision of hygienic buildings in suitable surroundings, the right kind of furniture and equipment and ample facilities for physical training and games.

(9) Special schools for children suffering from mental or physical handicaps.

(10) Recreational facilities of all kinds, to satisfy the craving for corporate activity and to counteract the drabness of the conditions in which so large a part of the Indian people otherwise spend their lives.

(11) Employment Bureaux, to guide school and college leavers into profitable employment and so far as possible to adjust the output of the schools to the capacity of the the labour market.

(12) An administrative system which will place initiative and authority in the hands of those who understand and care about education.

4. These requirements can hardly be described as extravagant. They were all covered by the British system of Education as it existed before the war, while in many parts of the United States of America and in some European countries a still more liberal provision of public instruction was available. Plans are already in preparation for substantial additions to the British system after the war. Let us therefore consider, also as briefly as possible, how far the Indian system, as it exists today, falls short of these desiderata and whether it is practicable to build upon it a national system on the lines which have been already outlined. I will take the requirements in the order in which I have set them out.

(1) *Education at the Primary and Middle stages.*—In England before the war all children were required to attend school for a minimum period of nine years, *i.e.*, from the age of 5 to the age of 14. In many States of the U. S. A. and in some European countries the period of compulsory attendance exceeded this by 1 or 2 years, and from pronouncements which have already been made, it appears very likely that in post-war England the leaving age will be extended to 15, if not to 16, probably with compulsory part-time education for another two years. In India compulsion exists in only a very limited number of areas, usually towns, and then it only covers the primary stage, *i.e.*, up to the end of Class V or approximately the age of 11. Even in the majority of these cases compulsion is admittedly a failure, partly because there is no organised system of attendance officers to see that children attend school and partly because the Courts have been reluctant to enforce the law.

As things stand, the latest figures available (Public Health Commissioner's report, 1940) indicate that in British India there are 6,27,78,000 children between the ages of 5 and 14. In 1936-37 (11th Quinquennial Review) there were 1,19,85,986 pupils on the registers of some school or other. This, however, gives a very misleading picture of the actual position. Of these children 51,88,601 were in Class I, 23,55,418 in Class II, 17,22,292 in Class III, 12,14,504 in Class IV, and 7,03,628 in Class V. Figures for previous years record a similar falling off. This means that less than 1 out of every four children stayed long enough at school to reach the earliest stage, *viz.*, Class IV, at which permanent literacy is likely to be attained. The result is that the money spent on the others (nearly 80%) may be regarded as almost entirely wasted.

Apart, however, from the factor of wastage, which could, of course, be removed if an effective compulsory system were introduced, there is a still more serious matter which militates against the efficiency of the instruction. In any country and in any circumstances the standard of a school is determined by the standard of the teaching. There have always been in India, as elsewhere—and it may be hoped there always will be—a number of people who enter the teaching profession because they like teaching or because they regard it in the light of a vocation, but such people unfortunately will never constitute more than a very tiny part of the vast army of teachers which a national system requires. The remainder will have to be attracted into the profession by reasonable prospects and conditions of service. Since the average pay of a primary teacher in Government schools in India is about Rs. 27 per mensem, and in private schools is actually much lower—in one of the largest provinces the average is below Rs. 10 per mensem—it can hardly be said that the teaching service in India is likely to attract the sort of people who ought to be in charge of the nation's most valuable asset, *viz.*, its children, during its most malleable stage. In Great Britain the scales of salaries of ordinary assistant teachers in primary schools range from £150 to £408 per annum.

Between the ages of 11 and 14, there were 5,94,045 children in British India in 1936-37 in middle schools including the middle departments of high schools (11th Quinquennial Review). In 1940 the available school population in this age group was 1,95,49,000 (Public Health Commissioner's report, 1940). Here also the conditions in regard to buildings and salaries, though superior to those in primary schools, fall hopelessly short of normal modern standards elsewhere. It has to be remembered that under a compulsory system 80 per cent of the future citizens of the

country will finish their full time education at the end of the middle stage.

The present position cannot be excused on the ground that no guidance is available as to the ways and means of doing something better. In 1938-39, the Central Advisory Board of Education appointed two committees, who prepared schemes for the introduction of a nation-wide system of basic education, *i.e.*, education through craft or activity, covering the years 6-14. Five provinces have begun to introduce basic education on the general lines recommended by the Board but it is still very far from being either universal or compulsory in any of their areas and so long as education is financed on the present basis, there is no prospect of its becoming so.

So far as teachers are concerned, the Central Advisory Board also set up a committee in 1942 to consider the whole question of their recruitment, training and conditions of service, including scales of salary for teachers in all grades of schools up to the end of the high school stage. This report, about the recommendations of which I shall have more to say later, was unanimously adopted at the last meeting of the Central Advisory Board of Education in January, 1943, at which every province was represented. A significant recommendation, both of this Committee and of the Committee on Basic Education, implied a recognition of the fact that to encourage and indeed to enable Provincial Governments to give effect to the reports, substantial financial assistance from the Central Government would be necessary.

(2) *Pre-Primary Education.*—As stated above, the minimum age for the basic system of education has been fixed at 6 years. Many people, including myself, regard this as too late an age for the great majority of children to start their schooling, particularly from the physical point of view, because experience has shown that many defects, which ought to be remedied quickly, reveal themselves before this age. If 6 is retained as the minimum age for compulsion, it seems necessary, particularly in town areas where housing conditions are unsatisfactory, that basic education should be supplemented by a generous provision of nursery and infants' schools and classes for children below the minimum age for compulsory attendance. Partly owing to expense and partly owing to the dearth of trained women teachers, who alone should be in charge of children at this tender age, provision of this kind is practically non-existent in India today.

(3) *High School Education.*—Here the disparity between what is and what ought to be is not so apparent, at any rate at first sight, as it is in the lower stages of education. In British India there are rather less than 4½ lakhs of pupils in Classes IX, X and XI of high schools of various kinds. To these must be added a number of pupils in Classes VI—VIII which form part of High Schools; the number of these is not known but may be assumed to be between 5 and 5½ lakhs. On investigation, however, it will be found that there is practically no selection, admission being determined by ability to pay fees rather than intellectual promise, and there is still less variety. The curriculum in the great majority of cases is stereotyped by the requirements of university matriculation and offers hardly any facilities specially designed for those pupils who will not proceed to a university in any case and will probably seek employment in industrial or commercial occupations. Very little is done to cater for any interests outside specific examination requirements, to encourage corporate activities or to inculcate a sense of loyalty and responsibility. Free places, scholarships and stipends to provide

opportunities for poor children of outstanding ability are inadequate both in quantity and in amount.

(4) *University Education.*—Here the facilities available are by no means adequate to satisfy the needs of a literate India. On the assumption that one pupil in every fifteen leaving a High School should proceed to a University, about 2½ lakhs of places will be required under a national system; this is about double the number of students now in Indian Universities, if those in the 1st year of the Intermediate Course are excluded. As things are, however, the existing provision is probably larger than the lower stages can supply with properly trained recruits. It is significant that in India today the proportion of university students to pupils in High Schools is 1 to 7 whereas in Great Britain it is only about 1 to 10. I do not propose to repeat the criticism of Indian Universities which are often made, sometimes by people who do not appreciate the difficulties, financial and otherwise, under which they are working nor do I wish to overlook their many admirable features. At the same time it would appear to be true that Indian Universities do not make any serious attempt to relate their output to the needs of the community, that their examination system does not encourage original thinking and real scholarship and that their general organisation does not secure that close personal contact between students and teachers from which the greatest benefits of University life are usually derived. The conception of a University as an Alma Mater in the literal sense of the words, to whom affection and loyalty are owed, is limited to comparatively few.

(5) *Technical, Commercial and Art Education.*—The provision in this respect has been hitherto restricted partly by the limited number of openings in industry and commerce and still more by the fact that it has been the practice to fill many of the better openings that are available by imported technicians. It is reasonable to expect that a considerable development in this branch of education will be called for in the post-war period. It has already been given an impulse in the right direction by the war training schemes which are now in operation. The Central Advisory Board of Education at its last meeting set up a Commitee to examine this subject.

(6) *Adult Education.*—At least 85 per cent of the population of India is illiterate. No further comment would appear to be needed. It is clear that if the problem of illiteracy is to be dealt with as efficiently and quickly as appears to have been the case in Russia, it will have to be attacked at both ends, *i.e.*, by the establishment of universal, compulsory and free primary education and by the provision at the same time of abundant facilities for those whose education was neglected in their earlier years. Some of the popular Governments immediately before the war initiated mass literacy campaigns. Much enthusiasm was generated in some areas and good work was undoubtedly done but the astronomical statistics which have been published in regard to these movements need to be treated with the utmost reserve. Literacy campaigns must be very carefully planned from the point of view of following up and consolidation, if permanently useful results are to be achieved. How this might be done has already been set out in a report by a Committee which was set up by the Central Advisory Board in 1939.

(7) *Training of Teachers*—42 per cent of the existing teachers are untrained. As the Central Advisory Board have recognised, every teacher ought to be trained. Adequate arrangements for training and keeping up-to-date the number of teachers required are an essential preliminary to the introduction of a national system.

(8) *School Medical Service.*—Sporadic attempts have been made from time to time in different parts of India to provide the nucleus of such a service. This has usually confined itself for reasons of expense to inspection only. The main result has been the collection of statistics. It is hardly necessary to point out that inspection without treatment is of little value, particularly in a country where the great majority of parents are unwilling or unable to act on any medical advice they may receive. Courageous attempts have also been made to supply nourishment for the children most in need of it. But again owing to lack of funds these attempts have been on far too small a scale to do more than touch the fringe of a problem which is extremely serious when the homes from which so many children come are close to the starvation line. What is still more depressing is the fact that the School Medical Service has usually been one of the first victims of the economy axe. In one Province, for instance, such a service has been initiated three times only to be discontinued as often on the plea of economy.

The less said the better, at any rate in the lower stages of Indian education about the buildings, equipment and other facilities such as playgrounds and playing fields, which are usually regarded as essential to any proper school in western countries. It should, however, be pointed out that here also the continuance of the present state of things is not due to lack of expert guidance as to ways and means of improving the situation. In 1941 a joint committee was set up representing the Central Advisory Board of Education on the one hand and the Central Advisory Board of Health on the other to consider generally the question of the physical welfare of school children. This Committee's report, which was adopted by both the parent bodies, sets out in detail a comprehensive plan for dealing with this vital problem, but so far as is known, neither the Central Government nor the Provincial Governments have yet found it possible to take any steps to implement the recommendations of the Committee. With regard to the question of school buildings, a special committee was also set up at the same time by the Central Advisory Board of Education to consider this matter. The committee produced a comprehensive report which was adopted by the Board. This report specifies in detail the minimum requirements in regard to sites, buildings, equipment, etc. for schools of all types and contains various recommendations for taking fuller advantage of the Indian climate and other local conditions in order to minimise the cost of school construction. There has been a considerable demand from all over India for copies of the report but it is not known how far the responsible authorities have been able to adopt its recommendations either in building new schools or in according recognition to existing schools.

(9) *Special Schools.*—Although no accurate statistics are available, there can be little doubt that owing to under-nourishment, neglect, unsatisfactory living conditions and other causes the number of children suffering from physical and mental defects is unusually high. Very little has been done for them, the responsible authorities arguing that their exiguous resources can be more profitably spent on educating normal children.

(10) *Recreational Facilities.*—Scouting and similar organisations flourish in many areas, but they are not co-ordinated as purely educational influences which satisfy the natural desire for corporate activity of most young people. Very few Boys' or Girls' Clubs exist in urban areas. The need for a Youth Movement on an All-India scale is obvious.

(11) *Employment Bureaux.*—These are practically non-existent ; in fact of all the criticisms that can be brought against the Indian system of Education today, probably the most serious is that it makes no attempt whatever to market the articles which it produces. So far as I have been able to discover, only in the rarest instances is any attempt made by the school authorities to advise parents as to the occupations for which their children are suited, to afford information as to the openings available in the area or to restrict the intake into any particular institution or course of study where it is clear that the labour market is incapable of absorbing the output.

(12) *Administration.*—Almost every provincial report I have ever read has called attention to the inefficiency of many of the local bodies to which responsibility for the lower stages of education has generally been delegated. It is indeed incredible that when it was decided to encourage Local Government in this country, it should have been thought desirable to hand over education of all subjects to the mercy of bodies themselves only too often either uneducated or uninterested in education or both.

Some reports have also called attention recently to the rapid deterioration of the educational administrative service. This may be partly due to the dying out of the Indian Educational Service but the main cause is the deliberate depression of the status and remuneration of educational administrative officers in comparison with other Services. This problem also was considered by a Committee of the Central Advisory Board in 1943 and the necessary steps have been suggested for retrieving the position.

It should also be emphasised at this point that if a national system is to be introduced within a reasonable period, it will have to be not merely subsidised but also stimulated and co-ordinated from the Centre. This means a strong education department in the Central Government.

It will be apparent from the foregoing that the present Indian system of Education, when considered either on its merits or in comparison with systems in other countries, is deficient in almost every branch, and that if any real progress is to be made, a large part of what exists today will have to be scrapped. It is true, of course, that there are good schools up and down this country and that in some universities, particularly in the science faculties, work of first-class standard is being done. There are also a number of research institutions which will bear comparison with any that can be found elsewhere. Obviously every attempt should be made to preserve these and fit them into any new system. Every expert who has examined the Indian system of education over the last 50 years or more has called attention to many defects, some of which I have enumerated. There has been universal agreement that the system apart from its general inadequacy is unco-ordinated and out-of-date. The main objective hitherto has been cheapness, and this has produced many of the results which are proverbially associated with cheapness. Because no plan has been followed, such development as has taken place has been haphazard.

5. What would it cost to bring Indian education up to approximately the same level as existed in other countries just before the war?

Expenditure in England and Wales* on Education from public funds in the year before the war (1938-39) amounted to £102,000,000 or roughly Rs. 33/2/- per head of the population (total population and not school

*Scotland has a separate educational budget and so has Northern Ireland. In 1938-39 Scotland spent £15,000,000 on education or Rs. 41-6-0 per head of population.

population). In the same year expenditure on education from public funds in British India (I have no reliable figures for the States) amounted to Rs. 16,43,76,903 or Rs. 0/8/9 per head of the population. But standards of living vary and may be expected to continue to vary greatly between India and Great Britain and there is no need to adopt a foreign basis, which may not be relevant to Indian conditions, for estimating what a national system of education for India would be likely to cost. Local data are now available on which a sufficiently accurate estimate can be based. In all forms of education the salaries of teachers are the factors that largely determine educational costs. In primary schools they may be taken as accounting for roughly 70 per cent. of the total expenditure, the balance being distributed very approximately as follows:—

	Per cent.
Loan charges on buildings and grounds	5
Special Services, including School Medical Service, provision of meals, special schools, etc. ...	10
Administration	5
Other expenditure, including books, stationery, apparatus, maintenance and repairs of buildings, etc.	10

At the post-primary stages of education, these percentages are liable to a good deal of variation in different branches of education and even in different institutions but for the purpose of a rough estimate the factor of 70 per cent. for teachers' salaries may be retained. As already stated, the Central Advisory Board of Education have recently adopted scales of salaries for all types of school below the university stage. The following are the scales for assistant teachers: —

SCALE FOR ASSISTANT TEACHERS.	REMARKS.
A. *Primary Schools (including Infants and Nursery Schools).*	
Rs. 30-1-35-3 (biennially)—50 per mensem.	1. Same scale for men and women. 2. Teachers of village schools should have free houses: Where this is not possible 10 per cent. should be added to their salaries. This scale, which has been framed for what may be described as normal rural areas may be increased up to 50 per cent. to meet the needs of areas where the cost of living or other factors necessitate a more generous scale.
B. *Vernacular Middle or Senior Basic Schools (and for Anglo-Vernacular Schools and non-graduate teachers in the Middle classes of High Schools).*	
Rs. 40-2-80 per mensem ...	Same provisos as in the case of Primary teachers.
C. *Graduate Teachers in High Schools.*	
Rs. 70-5-150 per mensem ...	Same provisos as set out above.

Cost of a universal system of primary and middle education and a selective system of higher education for one-fifth of each age-group.

BRITISH INDIA

	Age Range	*Estimated No. of pupils (Lakhs)	†No. of teachers required	‡Average salary per teacher per mensem	§Total salary bill per annum (Lakhs)	‖Other Expenditure (Lakhs)	Total gross cost per annum (Lakhs)	Cost per pupil per annum
	1	2	3	4	5	6	7	8
Primary Schools ...	6—11	3,60	12,00,000	Rs. 42-8	Rs. 80,00	Rs. 34,29	Rs. 114,29	Rs. 31·84
Middle Schools ...	11—14	1,56	6,00,000	Rs. 61-8	Rs. 60,55	Rs. 25,95	Rs. 86,50	Rs. 55·31
High Schools ...	11—17	72	3,60,000	½ at Rs. 61-8 ½ at Rs. 120-0	Rs. 18,69 Rs. 36,47	Rs. 23,64	Rs. 78,80	Rs. 109·44
		5,88	21,60,000		Rs. 195,71	Rs. 83,88	Rs. 279,59	

* The estimate is based on Public Health Commissioner's Report of 1940. Of the 11—14 age group four-fifths are shown in Middle Schools, one-fifth in the middle section of High Schools.

† One teacher to 30 pupils in Primary Schools, one to 25 in Middle Schools, one to 20 in High Schools.

‡ Average salary on the basic scales in accordance with Government's actuarial calculation.

§ Additions have been made for Head Teachers, higher scales in urban areas, house allowances, Govt. contribution to pensions or provident funds, etc. Teachers' salaries are taken as accounting for 70 per cent. of the total gross cost.

‖ This includes expenditure on (a) loan charges, (b) special services, including school medical service, special schools, etc. (c) administration, (d) books, stationery, apparatus and equipment, (e) maintenance and repair of buildings and furniture and miscellaneous charges. Other expenditure is taken as accounting for 30 per cent. of the total gross cost.

Whether these are extravagant figures or whether lower scales would be likely to attract the right sort of teachers are questions which I will leave to be answered by people who know more about Indian conditions than I do.

Assuming, however, that Rs. 30 per month is not an excessive starting salary for the men and women to whom the training of the bulk of the rising generation will be entrusted, the next factor we have to determine for the purpose of our estimate is the ratio of teachers to pupils, as this will give us the number of teachers required. I hope that if for the purpose of my estimate I allow 1 teacher to every 30 children in Primary Schools, 1 to every 25 in Middle Schools and 1 to every 20 in High Schools, I shall not be accused of being over-generous in regard to staffing. Adopting these ratios and using average salaries for the teachers based on the scales already set out, we can arrive at an approximate estimate of the cost of providing for British India a universal system of primary and middle education and a selective system of higher education for one-fifth of each age group.

The sum of Rs. 279,59 lakhs represents the gross annual cost of what may be called the main block of the proposed educational structure. Reference back to the list of requirements for a national system will show that the top storey has still to be added together with certain essential wings and outbuildings and a highly desirable basement. A very approximate estimate of the gross cost of these necessary additions is set out below:—

(a) *Pre-primary Education.*—Rs. 3,18 lakhs. If the same proportion of children in India attended school voluntarily before the minimum compulsory age as in England, the number between the ages of 3 and 6 would be 35,00,000; 10,00,000 have been taken for the estimate and the cost per head has been taken as the same as that for Primary Schools (Rs. 31·84 p.a.) though it will probably work out somewhat higher in practice.

(b) *University Education.*—Rs. 9,60 lakhs. In accordance with the reorganisation of the stages of education approved by the C.A.B. in 1935 and adopted for the purpose of this paper, the normal university course in future will cover 3 years. This means that the first year of the present Intermediate course will be transferred to the High School and the second year will become the first year of the degree course. The estimate provides for 2,40,000 students at a cost per head of Rs. 400 per student (excluding maintenance). This is approximately 33½ per cent. above the present average cost and makes provision for certain essential improvements in lecturers' salaries, reductions in the size of classes, more tutorial work, etc.

(c) *Technical, Commercial and Art Education.*—Rs. 10,00 lakhs. It is impossible to forecast the future demand for this form of education, as it will largely depend on the nature and extent of industrial development. For the purpose of this estimate it has been assumed that apart from pupils in Technical High Schools, who have been provided for under the general heading of High Schools, about 1 lakh or nearly 4 per cent. of the boy pupils leaving Middle Schools will continue their education, either full-time or part-time, for a period of 2 years in Junior Technical, Trade or Industrial Schools with a view to becoming skilled artisans. This means the equivalent of 2 lakhs of places at Rs. 150 per head. It has also been assumed that at the end of the High School stage, in addition to the pupils who enter the technological departments of universities, 25,000 leavers each year (which is about 4 per cent. of

the boy leavers) will enter Technical, Commercial and Art Institutions for courses, full-time or part-time, covering three years. These students will be prepared for positions in industry superior to that of the skilled artisan. This means the equivalent of 75,000 places at Rs. 500 per head. Provision has also to be made for a large number of part-time students, both day and evening.

(d) *Adult Education.*—Rs. 3,00 lakhs. Here again, since attendance will be voluntary, it is impossible to forecast how many students will be forthcoming. In the beginning the main objective will be the elimination of illiteracy. As this objective is progressively achieved the character of adult education will change ; the number of students will probably decrease but the standard of work will be higher and correspondingly more expensive. According to the most recent figures there are in British India 14,86 lakh persons between the ages of 10 and 40, of whom nearly 12,70 lakhs are illiterate. If illiteracy is to be removed in a period of 25 years, by which time a universal and compulsory system of Primary and Middle education should have reduced it to negligible dimensions, it will be necessary to deal with 67 lakhs of persons a year. On the basis of 25 students per teacher and an average payment per teacher per session (100 hours) of Re. 1 per hour with an additional 15 per cent. for other expenditure the average annual cost will amount to the figure given above. Since it is reasonable to count on the services of a number of voluntary teachers, this figure will leave a margin for adult education other than that primarily concerned with the removal of illiteracy.

(e) *Training of Teachers.*—Rs. 6,23 lakhs. This is the average annual expenditure. Since Matriculation or its equivalent has been prescribed as the minimum educational qualification for teachers, it will not be possible to increase substantially the supply of trained teachers until the output of the new High Schools becomes available. A careful calculation, based admittedly on certain assumptions, suggests that it will take 35 to 40 years to produce the vast army of additional teachers which a national system will require. In Training Schools the annual cost per place may be taken at Rs. 450 (Tuition Rs. 200, Maintenance Rs. 250) ; in Training Colleges Rs. 400 (Tuition only ; students may be expected as a rule to pay for their own maintenance).

(f) *Youth Movement.*—Rs. 1,00 lakhs. This is a purely hypothetical figure.

(g) *Employment Bureaux.*—Rs. 66 lakhs. The estimate provides for dealing annually with 52 lakhs of Middle School leavers and 14 lakhs of High School leavers at Re. 1 per head.

All the major requirements of a national system as set out in section 3 of this paper have now been dealt with except (8) School Medical Service, (9) Special Schools and (12) Administration. These, however, have been covered by the provision made for 'other expenditure' so far as the main block is concerned and under cost per head where necessary elsewhere.

Nothing has been said so far about the heavy capital expenditure which the carrying out of a programme of this magnitude will involve. It has been taken for granted—in fact it is a *sine qua non*—that any non-recurring expenditure, other than minor items, will in future be met from loan as in Great Britain. Provision has been made for the interest and sinking fund charges in this connection.

The gross annual cost of our national system has now risen to just over Rs. 313 crores for British India alone ; adding one-third to cover

the Indian States we arrive at a total of Rs. 417 crores for the whole of India.

6. It now remains to consider what amount of income we can reasonably anticipate as an offset against this heavy bill and whether there are any feasible means by which the bill itself can be lightened. Educational income, apart from grants from public funds, consists of receipts from fees and from such other sources as endowments, subscriptions, etc. So far as fees are concerned, it has generally been accepted that education which is universal and compulsory should also be free and I see no justification for adopting any different principle in the case of India. There will, therefore, be no receipts from this source in respect of the primary and middle stages. This covers Special Schools also. Since Pre-primary and Adult Education are mainly designed for the benefit of the poorer classes, they must, to achieve their object, either be entirely free or the fees must be nominal. The same applies to the School Medical Service and the Youth Movement. Employment Bureaux should be really regarded as part and parcel of the ordinary administrative service. If an adequate supply of teachers is to be obtained for the salaries proposed, it will not be practicable to charge fees in training schools or colleges.

This leaves the High Schools, Universities and Technical, Commercial and Art institutes as the only sources of fee income. If there is to be real selection for higher education—and all these branches fall within that category—liberal assistance must be forthcoming from public funds to enable poor boys and girls of ability to continue their education. Without attempting to lay down any special number or value of free places, scholarships or stipends, I propose to assume that these will require half the fee income which might otherwise have been expected or in other words that only half the pupils or students will pay the normal fee. Since those who will pay will be better off on the average than at present, it seems equitable to make the normal fees somewhat higher than they are today.

No provision has been made in the estimate of expenditure to cover the cost of maintenance of students in Universities, including Teachers' Training Colleges, apart from such maintenance allowances as may be granted (see above). It is assumed that these costs will be met in full by the students. In the case of Training or Normal Schools, however, the full cost of maintenance, viz. Rs. 5,00 lakhs has been provided. It is reasonable to anticipate that many students will be in a position to make some contribution towards this, and half the total cost, viz., Rs. 2,50 lakhs, may be recovered in this way.

The total receipts from other sources such as endowments and subscriptions came in 1938-39 to Rs. 4,11,25,072 and I should not like to count on this being greatly increased if a national system were brought into operation.

On the basis set out above, the estimated annual income from sources other than public funds will work out as under :—

High Schools	... ...	Rs. 29,00 lakhs.
Universities	... ...	Rs. 2,88 ,,
Technical Schools	... ...	Rs. 2,00 ,,
Training of Teachers	... ...	Rs. 1,68 ,,
	Total ...	Rs. 35,56

This leaves a deficit so far as British India is concerned, of roughly Rs. 277½ crores to be found from public funds or other sources of revenue not hitherto explored.

The total expenditure on education in British India in 1940-41 from public funds, whether Central Government, Provincial Governments, Municipalities or local bodies, amounted to Rs. 17,50,66,966 out of a total expenditure on education of Rs. 29,84,03,205. The total revenues of the Central and Provincial Governments for the same period amounted to Rs. 243,65,49,185. It would be justifiable in theory to deduct the amount of money now spent on education out of public funds from the sum given above, thus reducing the net additional cost of a national system to Rs. 260 crores per annum. It has, however, to be remembered that during the time it will take to bring the new system into operation there is likely to be a substantial increase in the school population. It may be prudent therefore to regard the sum now spent on education as a reserve to meet this contingency.

7. A brief reference may be made here to the ideas which have been advanced with the object of reducing the incidence of a national education bill. The best known of these is the Wardha scheme, which issued six years ago under Mr. Gandhi's auspices. This proposed to develop craft work in primary and middle schools to such a standard that the sale of articles produced by the pupils would cover the whole or the major part of the cost of education. Experiment in India has shown what experience elsewhere had suggested, viz. that such a hope is illusory. The most that can and should be expected of the sale of articles produced in school is that it should cover the additional cost of the materials consumed. The more enlightened protagonists of the Wardha scheme have now accepted this conclusion. Other systems, like the Vidya Mandir, aim at making the remuneration of teachers a local affair based in effect on payment in kind. The fatal objection to such expedients is that by making the teaching service static and restricting avenues of promotion they abolish the main incentive to teachers to keep themselves efficient and up-to-date. For obvious reasons also it is not desirable that the teacher should be too dependent on the locality for his livelihood.

The general conclusion to which one is driven by the results of these experiments is that if India wants a proper system of education, she will have to follow the example of other countries and pay for it. We are, therefore, brought back to the fundamental issue of finding ways and means of footing an educational bill of something like Rs. 280 crores. As long as teachers' salaries are taken at the figures suggested, any economies that can be effected in other expenditure will not alter the total figure to an extent that will affect the main argument of this paper, viz. that if India is to have anything approaching a national system of education, a drastic reconsideration of the whole basis of educational finance will become necessary.

I am neither a financial nor an economic expert and I am very doubtful whether I am competent to offer advice in a matter of this kind. One or two possibilities, however, suggest themselves. In the first place if after the war there is, as many hope, some kind of international police force to guarantee world peace and relieve individual nations of the burden of armaments, the Government of India may be able to divert to education a proportion of the considerable sum it now spends on defence.

Secondly, there is some reason to believe that there must be very considerable funds belonging to religious bodies, which are not being

used or are no longer required for the purposes for which they were bequeathed. If some impartial body on the lines of the Charity Commission were set up—I admit that it would take an Indian Government and a strong one at that to do it—it might be able after satisfying all legitimate claims of the religious bodies concerned to free a large sum of money for educational development.

• Thirdly, if as appears likely there is to be established after the war some form of international credit control, which among other things will make grants for the rehabilitation of the devastated countries, why should not India be regarded as eligible for assistance in the form of a long term loan? As a creditor country her own credit will presumably be good and so far as her social services are concerned, she has a strong case for being treated as on much the same plane as a devastated country.

8. As has been pointed out, most of the main lines of development have already been laid down by the Central Advisory Board but even so, given the will and given the funds it would in my opinion take at least 35 to 40 years to establish the sort of educational system which has been outlined in this paper. The work might be spread over 8 five-year programmes. The first would be devoted mainly to working out plans in details, reorganising the administrative system and setting up the Training Schools and Colleges necessary to provide the teachers required. During each of the seven subsequent periods an area roughly equivalent to one-seventh of the area of each Province would be taken in hand. It will be about 10 years after the end of this period before the full incidence of the cost of educational reconstruction will be felt. By that time it is possible that the industrial development to which many look for raising the standard of living in India to a level which will enable her to finance essential services out of her own resources, may have become an accomplished fact. Moreover, as education spreads among the rural population, there is reason to hope that it may lead to the abandoning of those superstitions and prejudices which for centuries have hung like millstones round the neck of the Indian peasant. A competent observer has estimated that with the removal of these, the standard of living among agriculturists might be raised by as much as 100 per cent. Others are even more optimistic. If there are any such prospects, they would more than justify an immediate loan of such a size as would enable a start to be made at once with educational reconstruction on the scale which I have advocated. It is in the world's interest as much as India's that this should be done and done quickly. People like myself who believe that given the chance the human race, not excluding Indians, is capable of progress, find it difficult to understand why if money in any quantity can be raised in war time the same cannot be done in peace-time, for what may be a still more world-saving purpose. At one stage in the preparation of this paper I dictated something to the effect that one day expenditure on education might be regarded as even more remunerative than expenditure on armaments. My stenographer, wishing either to save me from myself or to quote me as an authority in some domestic argument, altered 'armaments' to 'ornaments'. In my pessimistic moments, I am inclined to think that he was right. It is barely twelve months since I saw education described as a 'frill', which I believe is a form of ornament, in an official document. But at other times I am encouraged to believe that if the facts of the situation could be made clear beyond all reasonable doubt, men of good-will, whether Indians or British, would combine to do something about it. The object of this paper is to throw down a

challenge to all those who have the real welfare of India at heart. The question it propounds is as simple as it is urgent. What is not less important, it would appear in my humble opinion to transcend all political controversies. Federation will not answer it, nor Dominion Status, nor Non-violence, nor Pakistan. But the right answer to it may provide the right answer to all these. If my premises are accepted, there can be no half-way house between what is and what ought to be. It is all or nothing. All means expenditure on a scale which may frighten those who have defended inertia on the ground that India is too poor to have what other countries enjoy. Anything less than all means—and there is no evading this conclusion—that India accepts a position of permanent inferiority in the society of civilised nations.

SECTION OF ENGINEERING AND METALLURGY

President :—J. J. GHANDY, C.I.E.

INDUSTRIAL RESEARCH

(With special reference to India)

(Delivered on Jan. 4, 1944)

INTRODUCTION

I feel it not only a great honour, but a great privilege to preside over this Section, the Section of Engineering and Metallurgy. My only regret is I cannot profess to be as up-to-date in my knowledge of pure science as some of you whose entire career has been devoted to research, as it is many years since I cast off the academical robes of science and joined the iron and steel industry. I trust you will forgive me my consequent shortcomings.

The subject I have selected is Industrial Research, of the possibilities of which, my long association with the iron and steel industry has made me increasingly aware. Distinction is often drawn between 'pure' or 'fundamental' research and 'applied' research as if they were independent or un-related. To my mind, all research must be regarded as a means to an end, the end being the welfare of humanity. I am prepared to concede that pure or fundamental research brings knowledge to the research worker and knowledge brings happiness, but unless such research is pressed into the service of industry or generally 'applied' to the practical problems of life, it cannot be said to fulfil its purpose. To ascribe social value to it, is to exalt the means above the ends, the instrument above its function.

That research is the chief instrument of progress there can be no question. The entire industrial structure of the West has been reared on research. It serves no practical purpose to seek shelter behind our ancient cultural and philosophical heritage. We live in a competitive world in which it is not necessarily the best nation in the cultural or ethical sense, but the best fitted for economic survival that survives. Life, today, is a veritable battle, a chemical-mechanical battle, a battle of industries, a battle of fuel and steel and, in the last resort, a battle of research. Divorce research from industry and you ensure the beginning of the end of a nation.

INDUSTRIAL RESEARCH IN INDIA

Against a background such as this, one cannot but view with grave concern, our country's relative deficiencies in the field of research.

(a) *At the time of World War I.*—At the time of the first World War, research in India was chiefly confined to the official scientific services, like the Geological Survey, the Botanical Survey, the Departments of Agriculture and Meteorology and the Forest Department. The

Board of Scientific Advice constituted by the Government of India in 1902, which was eventually disbanded in 1924, co-ordinated the work of the various official agencies. The Indian Research Fund Association founded in 1911, carried out researches on diseases. The chief institutes of research were the Indian Institute of Science at Bangalore projected by our late Mr. J. N. Tata, the Forest Research Institute at Dehra Dun and the Agricultural Research Institute at Pusa. There were four engineering colleges at Roorkee, Madras, Sibpur and Poona, which concerned themselves mainly with the turning out of recruits for the Public Works Department. For mining education, there were courses at the Sibpur College and evening classes on the coal field.

Whilst the achievements of the official scientific services have been of outstanding benefit to India, it cannot be denied that those services were inadequately staffed, and, except in the Geological Survey and the Agricultural Department, the functions and powers of the experts employed were not properly classified or defined. The institutes of research also suffered from an inadequacy of staff. The four engineering colleges confined themselves to the relatively narrow requirements of the Public Works Department. The accommodation at the Sibpur College for students of mining was entirely inadequate, while the evening classes on the coal fields in the absence of a proper school of mines could provide no more than a limited range of instruction. The School of Mines at Dhanbad recommended by the Macpherson Committee in 1913/14 was yet to come into being.

The first World War brought the realisation in India—as in England, as we shall see later—that in a nation's struggle for economic survival, applied research was a major necessity. The Indian Industrial Commission appointed by the Government of India in 1916 to "examine and report upon the possibilities of further industrial development in India", reviewed the existing research facilities in the country and made detailed recommendations for their improvement and expansion.

(b) *During the interlude.*—With the return of peace, the enthusiasm for research waned, the lesson of the war was almost forgotten.

Yet, the research idea did not completely perish. During the period between the last war and the present war, the old scientific bodies continued to render outstanding service to India, and new bodies like the Imperial Council of Agricultural Research, the Indian Central Cotton Committee, the Indian Central Jute Committee and the Indian Lac Cess Committee appeared on the scene. Many of the universities improved their laboratories, added engineering, and, in a few cases, also metallurgy, to their curricula, and increased their staff.

The Tata Iron & Steel Company which had been busy on research connected with iron and steel, particularly since 1926, and had been feeling more and more the necessity of extended research facilities as it progressed with the years, completed new Control and Research Laboratories at Jamshedpur in 1937, which are perhaps the finest laboratories attached to any single steel-producing unit in the world.

Yet the fact remains that industrial research in India was still sporadic and unsystematised.

(c) *During World War II.*—The outbreak of the present war, laid even greater stress than the first war on the need for industrial research in India. The World had made rapid advances in science in the brief interlude of peace. Mechanization had almost reached its zenith. India's strategic position and the gradual diminution of imports with increased

shipping difficulties rendered it imperative for her, as never before, to develop her own war potential to the maximum. But this could not be accomplished except through systematic experimentation and research for which no adequate facilities existed in the country.

BOARD OF SCIENTIFIC AND INDUSTRIAL RESEARCH

In April 1940, in order to meet the imperious needs of the war, a Research Body known as the Board of Scientific and Industrial Research consisting of a number of scientists and industrialists and presided over by the Commerce Member was brought into existence by the Government of India. This organisation has undergone considerable expansion since its inception, and today comprises

(*a*) A Council of Scientific and Industrial Research,
(*b*) A Board of Scientific and Industrial Research,
(*c*) An Industrial Research Utilization Committee, and
(*d*) A Committee for the publication of a Dictionary of raw materials.

The Council consisting of officials, industrialists and scientists is the sovereign body. Its main functions are to initiate proposals, exercise administrative control over the work of the lower bodies, and examine and approve or reject research proposals received from these bodies or from other research institutions, universities, individual scientists and industry, and secure funds from Government and the public.

The Board somewhat similarly composed as the Council is purely an advisory body which aided by some 20 research committees examines each research scheme submitted by official or non-official scientists, refers it to one of its many research committees and if necessary, gets it further examined by its technical committee and then forwards its recommendations to the supreme Council for final approval.

The Research Utilization Committee composed largely of industrialists advises on the commercial utilization of researches completed by the Board.

Another Committee has been set up to compile for the benefit of Indian industrialists a Dictionary of Indian Raw Materials to replace the now out-of-date Watt's 'Dictionary of Economic Products'.

As the Board maintains only one Research Laboratory of its own, it has to get most of its research work done in other laboratories largely by staff not directly connected with the Board. I think it will be generally agreed that during the few years of its existence, the Board has been able to complete a number of researches valuable both from the point of war effort and for the industrial development of India.

It is not possible in the limited time at my disposal to set out in detail the various achievements of the Board. I can only make a passing reference to a few of the many items that have been investigated. Its work on coal tar and its products, synthetic drugs, the preparation of vitamins, paints and varnishes, plastics, vegetable dyes, de-colourising vegetable oil and mineral oils, the design and construction of electro-accoustical and high frequency apparatus, X-ray transformers, and the extraction of sulphur from the sulphur-bearing rocks in Baluchistan, has been of considerable practical value.

With the help of the Board, the Forest Research Institute, Dehra Dun, has turned out packing cases for army boots, timber for aircraft construction and for machine nailing tests, for ammunition boxes and for shuttles ; and the Government Central Weaving Institute, Benares, has

designed and constructed an automatic tape-loom, a twisting machine and a multiple treadle winder.

The importance of the synthetic dye industry which was first developed in Germany, is today commonly recognised as the basis of the synthetic chemical industry. The investigations of the Synthetic Dyestuffs Committee have considerably increased the possibility of the establishment of this industry in India.

Though much has been done by the Board, it cannot yet be said to be much beyond the prefatory stage. The paucity of laboratories, apparatus, and trained staff in the country cannot but hamper the progress of research in the country. Aware of this deficiency, the Board has had under contemplation the establishment of a National Chemical Laboratory at Poona, a National Metallurgical Laboratory at Jamshedpur, a Fuel Research Laboratory at Dhanbad, a National Physical Laboratory, a Central Glass Research Institute, a Food Technological Laboratory, etc. Not until are these laboratories brought into existence will it be possible for industrial research to keep pace with the needs of this age.

There is a number of scientific institutes in the country, like the Indian Science Congress Association, the National Institute of Sciences, the Royal Asiatic Society of Bengal, the Indian Academy of Sciences, Bangalore, and the National Academy of Sciences, Allahabad, but in the absence of a supreme national academy, there can be no assurance that their work is properly co-ordinated or there is proper collaboration between them, with no unnecessary duplication of effort.

TATA'S LABORATORIES AT JAMSHEDPUR

I mentioned the new Control and Research Laboratories of the Tata Iron & Steel Company at Jamshedpur in an earlier section. They represent the first large-scale research laboratories constructed by private industry to reap the full fruits of research. Time has more than justified their construction. Thanks to these research laboratories, the Steel Company today, is able not only to turn out unprecedented tonnages of ordinary carbon steel and structural products, but also develop and supply a rich variety of special steels for machine tools and surgical instruments, for armour plate, explosive and armour-piercing shells, helmets, parachute harness equipment, etc. to meet the varied requirements of the War.

As industrial development today depends largely on special steels, it may be said that the special steels developed by Tatas, in addition to being most essential to the War in the immediate present, constitute an insurance for the future industrial development of India.

INDUSTRIAL RESEARCH IN THE WEST

Though the realisation has come that organised research, pure and applied, is an absolute necessity in the present-day economic conditions of life, our research organisation in this country is still in the stage of infancy and the fields of industrial research yet to be covered are vast and boundless. How best this organisation can be improved, developed and expanded must be uppermost in many minds. Let us turn to the history of research in some of the advanced industrial countries of the West, and see what lessons it provides to guide our infantile steps.

(a) *Research in Germany.*—The first country to organise industrial research was Germany. The war of 1870 brought the realisation that

State aid to science was an absolute necessity if the new Reich was to maintain its position in the world. This led to the foundation of the famous Reichsanstalt in Berlin in 1886-87.

The Reichsanstalt.—Of its two divisions, the one concerned itself with pure science, dealing largely with questions connected with the fundamental units and standards of physical measurements, and the other with the application of the results of these investigations to German industry and manufacture. Technical colleges were also established as at Charlottenburg and Darmstadt, and a flow of scientific discoveries of industrial value came from their professors and students. Chemical, metallurgical and electrical industries, amongst others, were quick and farsighted enough to take full advantage of the discoveries of research and some of them eventually set up their own laboratories to develop for themselves the results of scientific investigations.

The work of the Reichsanstalt has been of historic importance in the growth of scientific and industrial research in Germany. Much of the standard equipment for measurements of precision, which is in use all over the civilised world today, has been developed by the Reichsanstalt. To it is also due the credit for the application of the precision methods of measurement to the establishment and control of the legal units.

Nor has the Reichsanstalt worked in isolation from the rest of the world. It has freely co-operated with foreign State industries with similar aims, such as the Bureau of Standards at Washington and the National Physical Laboratory at Teddington, and has participated in international scientific conferences dealing with questions connected with physical and technical units of measurement.

Co-operative Research.—I have dealt so far largely with the Reichsanstalt, which is a state organisation for research. Reference must be made to the organisation of co-operative research by industries themselves. The outstanding society for the promotion of sciences in Germany is the Kaiser-Wilhelm Gesellschaft founded in 1911, which maintains a number of institutes, one for natural sciences, a second for applied chemistry and physics, a third for research on coals, a fourth for research on iron and steel and so on.

Of these institutes, perhaps the best known is the Kaiser-Wilhelm Institute fur Eisenforschung in Dusseldorf for research in ferrous metallurgy. It is financed chiefly by the German iron and steel industry through its organisation, the Verein deutscher Eisenhuttenlute.

The Institute has seven sections for research—for research on iron ores, and for metallurgical, technological, chemical, mechanical, physical and metallographic research. The work done at the Institute has undoubtedly been of paramount importance to the German iron and steel industry.

The State Council for Research.—No account of industrial and scientific research in Germany can be complete without a reference to the State Council for Research, founded in March 1937. It was not to replace the Kaiser-Wilhelm Gesellschaft nor disturb its status. The two were to work in co-operation, both being under the common supervision of the Reichminister, Herr Rust.

The rise of the Council symbolised the rise of a spirit that was at once old and new in Germany, the spirit of subordination of all learning to narrow, national ends. As Herr Rust himself said : "The Council is initiated at a moment when the German people is preparing, in a manner hitherto unprecedented and by an unexampled expenditure of its utmost effort, to win its rightful foundations of existence, independent of its

environment . . . . With the foundation of this Council no new principle of scientific behaviour is introduced. . . . What is new is the determinate and planned co-operation of technology and of science for the self-sufficiency of German economy".

These words were spoken in 1937, two years before the outbreak of the present War. Research was to be regimented towards one single end, the glorification of the State—an end towards which every other effort was to be directed with a single mind. The inevitable outcome of this spirit has been the present War, which has called for an unprecedented sacrifice of blood and treasure. Here was an instance of perversion of science, the fault lying, not with science itself but its application, with the people who planned the co-operation of science, not with constructive but with destructive ends.

(b) *Research in England.*—In England, the history of scientific and industrial research prior to the outbreak of the first World War was largely a history of individual inventors and investigators like Bessemer and Parsons, Newton, Watt and Faraday. Organised research was unknown. The rich natural resources of England and her strategic geographical position had brought her incomparable prosperity. Industrial opportunities were so numerous and so easy that the industrialist did not feel the same impelling need for research as in countries like Germany with inferior natural resources. The establishment of the National Physical Laboratory at Teddington in 1899 for the maintenance of physical standards, the testing of instruments, and the assistance of industry by advice and experiment, and a system of grants-in-aid to the Universities and the Royal Society for the advancement of science, were considered sufficient to ensure the progress of industry.

The Department of Scientific and Industrial Research.—The outbreak of the first World War revealed numerous gaps in England's industrial structure. She was found wanting in a number of essential war industries, such as the fine chemical industry and the scientific instrument industry. The realisation dawned that research and industry must be brought into close co-operation not only to meet the future needs of peace, but also the more immediate, vital needs of the war. Happily, the availability of a numerous body of University men of liberal education, possessing trained minds capable of easy adaptation to new situations, solved the question of scientific man power. What was needed was an organisation to mobilise the scientific talent of the country to the immediate ends of the war, and subsequently, to those of peace. The answer was the Department of Scientific and Industrial Research formed by Government in 1915 for scientific and industrial research, the Medical Research Council in 1920 for medical research, and the Agricultural Research Council in 1931 for agricultural research.

The formation of the Department of Scientific and Industrial Research marked the beginning of a new era in England, the era of organised research. The Department consisted of a committee of the Privy Council at the head to lay down research policy and secure financial assistance from Government, and an Advisory Council, consisting of scientists, to initiate specific researches, establish scientific institutions, and encourage scientific students by means of awards. Though the Committee was the superior body and received reports from the Advisory Council, it never interfered with the decisions of the Council, which was, thus, virtually autonomous.

The new Department soon came to grips with its tasks. It set up a Fuel Research Board, with a large laboratory at Greenwich to conduct

research work on coal ; a Building Research Station near London to investigate problems connected with the better housing of the people ; a Forest Products Research Laboratory for the study of the use of timber ; a Food Investigation Board for the study of problems connected with food, including its storage and transport ; a Road Research Station at Harmondsworth to grapple with questions of road construction ; and a Chemical Research Laboratory at Teddington for chemical research.

The mother department also took under its wing, the National Physical Laboratory at Teddington, and administered aid to the work of the aeronautical research committee, which has contributed in no small measure to the science of aviation.

These organisations benefited industries as a whole by bringing research to bear on problems connected with the day-to-day life of the people, but left the specific problems of individual industries unsolved. Whilst large-sized concerns, such as, in the metallurgical, electrical and chemical industries, were able to set up research stations of their own, small-scale factories, which constitute the greater bulk in England, could not afford the expenses of a private research laboratory. For the benefit of such small-scale firms, a Research Association Scheme was formulated in 1917 and £1,000,000 provided for its operation.

Co-operative Research.—Financed partly by Government and partly by member firms and based on voluntary co-operation between contributing members and with other bodies engaged in scientific research, the Research Association Scheme has fully justified itself. Today, there are some twenty research associations covering a wide range of industries in Great Britain, for example, the British Non-Ferrous Metals Research Association founded in 1919 and supported by nine Trade Associations, the British Cast Iron Research Association, and the relatively recent Welding Research Council.

For co-operative research on iron and steel, there is the Iron & Steel Industrial Research Council, which operates as a section of the British Iron & Steel Federation and works in close association not only with the Federation, but also the Iron and Steel Institute. Having no laboratories of its own, it conducts its researches in the laboratories of member companies and also in University Laboratories. The Council thus represents an excellent example of co-operation between Government, Industry and the University for the benefit of the community at large.

The University.—The British universities have provided a flow of research workers for industry in the past. Yet it is felt that the collaboration between the universities and industry is not close enough. At present, the bulk of technologists come not from Cambridge or Oxford, or London, but from the provincial universities, and most of them are from secondary and elementary schools. The public schools have a decided preference for the humanities. It is therefore advocated in certain responsible quarters that there should be a large financial provision to cover scholarships and grants to attract sufficient scientists to the universities and technical colleges and that the possibilities of extending the universities and setting up new foundations should be explored.

This should serve to indicate the importance that has come to be attached to the role of the university in the national scheme of industrial research and should serve as a lesson to us in India.

RESEARCH TODAY

The outbreak of the present war made new demands on the scientific talent of the country. The Board of Industrial and Scientific Research,

created during the last war, was fortunately available to measure up to these demands, whilst the war-time appointment of three scientific advisers to the Ministry of Production has tended to supply whatever deficiencies there might have been in the research organisation. Yet it is stated that there is room for better integration of research with the Supply Ministry. Mr. E. D. Swann proposed on behalf of the executive of the Association of Scientific Workers last year that a Central Scientific and Technical Board with wide executive powers should be established to work in direct contact with the War Cabinet, so as to bring the country's scientific talent into closer relation with the strategy determined by the Cabinet. Authorities like Dr. P. Dunsheath and Dr. H. Moore have commented on the inadequacy of the proportion of the annual turnover now being allocated to co-operative research and have advocated a manifold increase. This serves to show that research is essentially progressive, and its organisation, no matter how perfect at one time, may have to be altered and adjusted from time to time to suit changed sets of conditions.

(c) *Research in America.*—In America, both individual research by companies and co-operative research by trade associations have made great headway in recent years.

Research by Private Companies.—Of research organisations maintained by companies, mention may be made, by way of example, of the Bell Telephone Laboratories, Inc., in New York City, which employ some 5,000 to 6,000 research workers on telephonic communication, the laboratories and chemical organisations of E. I. du Pont de Nemours and Co., Wilmington, and the laboratories of the General Motors Corporation at Detroit ; and the General Electric Co., at Schenectady.

A number of companies, for example, the Graselli Chemical Company, make grants for research to educational institutions and a number take advantage of the research facilities offered by certain commercial laboratories in the country.

Co-operative Research.—Co-operative research takes many forms in America. Some associations have founded their own laboratories, some sustain fellowships or scholarships in educational institutions, some make use of the laboratories of professional consultants, some take advantage of what is known as the industrial fellowship scheme, and others co-operate with Government departments and bureaus under the "research associate plan."

Of these various forms of co-operative research, the industrial fellowship scheme and the research associate plan have proved of such great importance as to deserve more than a passing mention here.

The Industrial Fellowship Plan.—The father of the famous industrial fellowship idea was Robert Kennedy Duncan. During his travels in Europe in 1905 and 1906, he observed that in Germany, France, Italy and England, new scientific knowledge was being harnessed to the service of industry and much money spent on intelligent experimentation. Denied the fruits of applied Science, particularly of chemistry, American manufacture was naturally in a state of chaos and confusion, with an endless array of vital problems unsolved.

The example of European countries Duncan visited, inspired the belief that with the aid of the Universities and their laboratories and libraries, the American industry could be drawn out of the doldrums and set on the path to progress. The appointment of Duncan as professor of industrial chemistry at the University of Kansas after his return from

Rome in 1906 furnished a suitable opportunity for experimentation with this idea. A company engaged in the manufacture of launderer's materials, which believed that research could discover improvements in the chemistry of laundering and was prepared to pay for such research, provided the practical stimulus. Bringing the University of Kansas to the help of the Company, Duncan created the first industrial fellowship in American history on the basis of an agreement drawn up between the university and the donor company, the Fellow selected being W. F. Faragher, who, later, entered the services of the same company.

The first fellowship achieved such great success as to encourage Duncan to start further fellowships. Soon the number reached ten.

The Mellon Institute.—Further successes awaited the Fellowship plan. Impressed with its possibilities, the famous Andrew W. Mellon and his brother Richard B. Mellon prevailed on Duncan to organise a Department of Industrial Research in Pittsburgh in 1911 with eleven fellowships. In March 1913, came to be established the now famous Mellon Institute of Industrial Research and School of Specific Industries at the university of Pittsburgh, a symbol of co-operation between the factory and the university. If an individual or a company or a group of individuals or of companies wished a problem to be investigated, it would propose its investigation. If the problem was such as to require the services of a whole-time man for not less than a whole year and was not already under investigation, the Institute, subject of course, to limits of accommodation, would accept it for investigation, engage a trained worker and provide him with a laboratory, a library, a machine shop, and secretarial and other assistance. The individual or company interested would contribute the foundation sum of the fellowship and meet all operating expenses. The results of the fellowship belonged exclusively to the donor and could not be published without his consent. The Institute received no financial benefit from any fellowship except the satisfaction that it was furthering the cause of American industry.

The Institute has always looked ahead during the last thirty years of its existence. It is now housed in a new building, modelled on the style of the ancient Grecian architecture, which took many years to plan and six years to construct and was completed in 1937. Combining beauty with utility, and providing the most up-to-date facilities for research in most pleasant surroundings, the building, should enable the Institute to fulfil its purpose even more amply in the future than in the past.

The research spirit has spread to many other states and educational institutions in America. The Battelle Memorial Institute in Columbus, Ohio, founded in the 20's, the Purdue Research Foundation at Purdue University, West Lafayette, Ind., incorporated in 1930 ; the Ohio State University Research Foundation established at Columbus, Ohio in 1936 ; The Armour Research Foundation incorporated in 1936, and the Institute of Paper Chemistry founded at Appleton, Wisconsin, in 1929, and other research associations symbolise the same spirit as the Mellon Institute.

The Research Associate Plan.—The Research Associate Plan has its basis in a legislative enactment which makes the scientific and technical research facilities of various Government departments available to duly qualified workers. Associations or specific groups have their research workers employed in these departments to further research on problems of interest to them and the results of the investigations of these research workers or "associates" are made available to the industry concerned.

Co-operative Agencies.—America has also a number of agencies for the promotion of co-operative research, such as, the National Research

Council, which is a general "clearing-house" of research information, and the American Engineering Standards Committee and the American Engineering Council which collaborate with trade associations and individual concerns for the furtherance of research.

Federal Research.—In America, the Federal Government has greatly assisted the progress of research not only through its research associate plan, but also through the direct activities of its own research departments. In 1938, the immediate pre-war year, the Federal Budget showed an expenditure of 57·7 million dollars for different categories of research, the bulk being for natural sciences, engineering, and surveys and mapping.

Federal research in America is organised on a vast scale and embraces varied fields. The Department of Agriculture in America, considered to be the largest single research institution in the world, has done much for agriculture. Fundamental aeronautical research conducted by the National Advisory Committee for Aeronautics at Langley Field, Va., has practically revolutionised concepts of national defence. The geological survey has been responsible for the discovery and exploitation of mineral resources. The Bureau of Agricultural Chemistry and Engineering has done much useful work on farm products, fertiliser resources and agricultural engineering, whilst the Bureau of Dairy Industry of the Department of Agriculture has concerned itself with the development of diverse aspects of dairy products. The Bureau of Plant Industry has been able to make notable improvements in crops and agricultural practices, and that of Entomology and Plant Quarantine has developed improved insecticides for counteracting the damage done by parasites. The Bureau of Fisheries has been of considerable aid to American Fisheries. The National Bureau of Standards, now of international fame has developed new measurements and new standards of ever-increasing accuracy to meet the new demands of industry. The Bureau of Mines aided by regional experiment stations spread over the country has done singularly useful work on mining methods, on treatment of ores and other mineral substances and has successfully grappled with the nation's fuel and metallurgical problems.

(d) *Research in Russia.*—In Russia, organised research has come into its own only during the last twenty years or less. The Russian Academy of Sciences, founded by Peter the Great in the eighteenth century, possessed no constructive programme under the Tsars : it was more of an ornament to add to the pomp and lusture of the State than an instrument of organised research. It was only after the rise of the Bolshevik regime soon after the first World War, that the value of organised research came to be recognised in Russia. The problem that faced the country was one of transition from the agricultural to the industrial stage. In the new world born after the War, agriculture by itself was not enough to secure the economic survival of a nation. A nation had to industrialise or perish.

The new-born Russia applied itself with unequalled vigour to the problems of the time, and incorporating a carefully planned science organisation in the structure of the State, has pressed scientific research fully to the service of industry.

SCIENCE ORGANISATION IN RUSSIA

The main instruments of research in modern Russia are the Council of People's Commissars and the rehabilitated Academy of Sciences, both responsible to the Supreme Council, the highest elective assembly in the Soviet Union.

The Council of People's Commissars supervises the People's Commissariats of Education, Health and Heavy Industry.

The People's Commissariat of Education, as the name signifies, is in charge of education. It sees that a proper scientific bias is given to education. "Pioneer Palaces" or children's clubs, with their science laboratories and their exhibitions help the growth of a scientific outlook in the minds of young students, while, science courses at the schools and the universities and facilities for the conduct of research at the university laboratories in collaboration with the Scientific Research Institute of the Academy of Sciences, complete the scientific training of students and turn out a regular flow of scientific workers for the benefit of the community at large.

On October 3, 1940, a decree signed by President Kalinin introduced a system for the replacement of schools under the control of individual factories and commissariats by Government-controlled schools organised on a national plan. It was not long before a network of industrial technical schools came into existence in Russia, Moscow alone having seventy such schools towards the end of 1942, each specialising in a particular branch of industry.

Offering the attractions of a free education, free uniforms, and three free meals a day and guaranteeing decent employment at the end if a diploma is obtained, these schools have drawn hundreds of thousands of youths, including girls, in their middle teens, and have already provided tens of thousands of qualified workers for war industries.

The People's Commissariat of Health is responsible for medical research, and is in charge of hospitals and medical research institutes.

The People's Commissariat of Heavy Industry is responsible for power, and for metallurgical and electrical industries. It operates through a technical Education Sector, a group of industrial sectors, and a Scientific Research Sector.

The Technical Education Sector is responsible for technical training colleges and research laboratories.

The industrial sectors, responsible for different industries, administer production and distribution through what are known as State Trusts, and maintain research institutes for technical research on problems of general interest. For research on specific problems, each factory is provided with its own laboratory.

The Scientific Research Sector is concerned more with pure or fundamental research than applied research. It controls some of the best research institutes in the Soviet Union, like the Physico-Technical Institutes at Leningrad and Kharkov, the Institute of Chemical Physics at Leningrad and the Karpov Institute of Physical Chemistry at Moscow ; it apportions research work to these institutes as well as to the different factory laboratories and co-ordinates their activities in general.

Alive to the possibility of a German invasion and the danger of centralising research in regions relatively easily accessible to the enemy, Russia has also set up research institutes at Dniepropetrovsk and in the remote Ural area.

The Academy of Sciences, now located in Moscow, and interested mainly in natural sciences, sociology and technology, is responsible for the general planning and direction of scientific research and, in the drawing up of the Five-Year Plans in Russia, has been of immense scientific assistance to the supreme, national planning body, which is styled as the State Planning Commission.

INTERNATIONAL STANDARDS OF MEASUREMENTS

The progress of industrial research in various countries soon brought the realisation that it was essential to have international standards of measurement. Various laboratories and other bodies concerned with standards in various countries came to collaborate, leading to the formation of the Bureau International des Poids et Mesures at Sèvres and a number of other international associations, such as the International Electrotechnical Association or the Association for Testing Material.

This brief survey of the growth of organised research in Germany, England, America and Russia should serve to indicate our own vital weaknesses in this field. According to Professor Bernal, the Soviet expenditure on science is estimated to be 1 per cent of the national income, the United States' expenditure three-tenths of 1 per cent and England's one-tenth.

If the Soviet Union is now able to roll back the Germans like a carpet from occupied Russia, and America and England aided, of course, by the rest of the British Commonwealth, are striking vital blows from the air at the very heart of Germany and freeing Italy from the Axis grip, it is due, in no small measure, to the cumulative fruits of research, particularly those gathered during the recent years.

RESEARCH TODAY AND TOMORROW

Research has revolutionised our economic civilisation, particularly during the immediate pre-war and the war years, helping to swing up war production to the maximum with the minimum expenditure of materials, using substitutes for articles in short supply. It has improved radio communications, electric transformers, generators, motors and lighting equipment. It has discovered new applications for aluminium, such as in architecture, in marine construction, in the building of rail-road passenger cars, and in the manufacture of textiles ; and found new uses for plain carbon steels and cast irons.

Thanks to research, America is now able to manufacture chemical rubber for petroleum, recover magnesium from sea water, design trans-oceanic planes and think in terms of air trains of gliders.

Looking to the future, research opens up new vistas. Powder metallurgy, spectographic analysis, the ever-improving X-ray technique and the electron microscope, and colour cinematography will yield new wonders in the future. And, as Charles M. A. Stine, Vice-President, E. I. du Pont de Nemours and Co., writes in an article, "Molders of a Better Destiny", published in the journal, *Mining and Metallurgy*, December 1942: "We will have unbreakable glass and, glass that will float, wood that won't burn, and lamination of plastics and wood that will compete with the structural metals. Hosiery derived from air, water, and coal, a wonder of pre-war days, is but the fore-runner of many innovations from the same source, ranging from shoes that contain no leather and window screens that contain no wire, to machinery bearings that contain no metal."

Science has revolutionised not only the various industrial processes, but also our managerial concept. As stated in editorial comments on Dr. Dunsheath's Atkinson Memorial Lecture, in the magazine, *Chemical Age*, dated the 27th March, 1943: "Rightly or wrongly we are coming to the conclusion that the control of business by commercial man is

obsolete and will pass . . . . While financial skill is necessary for the sound operation of business, control should be vested in technically trained men. In our opinion, this would be the greatest single step towards making the fullest use of science in industry."

WHITHER INDIA ?

Where is India in this world of progress? We are not able to manufacture aircraft or automobiles. A proper ship-building industry is still unknown. Our requirements of heavy machinery have to be supplied from abroad and we are content to utilise the great reservoir of scientific talent that exists in the country for the purpose of maintenance and operation of machines designed and constructed in foreign countries. What heightens the sense of tragedy is the fact that a country so unusually rich in natural resources as India should be so backward in industrial development.

It is often urged that the War has filled many gaps in India's industrial structure. The statement is misleading. The gaps filled are relatively few and, by no means, of great importance: the major gaps are still unfilled. Even Australia and Canada have been able to accomplish much more in the industrial field than India and are now several paces ahead of us.

We have heard of long-range programmes of economic development for India, covering a whole range of large, medium and small-scale industries. But unless the magic wand of research can touch the country's raw material resources, no major industrial advancement is possible. And what facilities have we for research as compared with the countries of the West?

There are no national laboratories for physical, metallurgical, fuel, glass or cement research, no organisation for the promotion of co-operative research among relatively small concerns, no bureau of standards and measurements, no proper liaison between industry and the universities.

There can be no doubt today that if India is to survive in the post-war world of progress and competition, in which there will be more of international co-operation and less of national tariff protection, and efficiency will be the main criterion of success, we must draw up a blue-print of what our research organisation should be after the war, and do so now. There is no time to be lost.

RESEARCH ORGANISATION FOR INDIA

To my mind, national research must be planned on national lines in order to prevent clashes of sectional interests, territorial and occupational, and obviate unnecessary over-lapping of work and the consequent waste of money and effort. It must be adjusted to the economic structure of the country and not be a blind repetition of some foreign model. The Government, the University and Industry, each must be assigned distinct research functions, though all three must work in close collaboration towards the same end. The changes necessary, in my opinion, to ensure proper progress of research in India will be indicated in the succeeding paragraphs.

THE RÔLE OF GOVERNMENT

The existing Board of Scientific and Industrial Research in this country has come in for much criticism, particularly of late. It is

said to be a defective imitation of the Department of Scientific and Industrial Research in England. Some critics have gone so far as even to suggest that it should be disbanded and replaced by an entirely new department constituted on exactly the same basis as the British model. I for one feel that this is going too far. The Board has proved its usefulness though I must admit, on a very limited scale, and there is no reason why, with certain changes in its composition and a better classification of the functions of its constituent bodies, as indicated later, it should not be able to fulfil its purpose.

The main constituent bodies of the existing department are a Council of Scientific and Industrial Research, a Board of Scientific and Industrial Research and an Industrial Research Utilisation Committee.

The Council of Scientific and Industrial Research which is the supreme body should correspond in its functions to the Committee of the Privy Council for Scientific and Industrial Research in Great Britain and consist of prominent industrialists, economists and scientists, and be presided over by an appropriate member of Viceroy's Executive Council.

Its main functions should be to lay down broad principles of policy for the guidance of the technically subservient bodies, co-ordinate their activities and receive financial grants from Government.

Of the other two constituent bodies, the Board should concern itself largely with science and the Committee largely with industry, or rather, with the industrial application of scientific research, both working in close collaboration, under the general guidance of the supreme Council.

In order to enable the Board to discharge its scientific functions properly, it will be essential to select, preferably in consultation with the leading scientific societies and academies in the country, representatives of all branches of science and include them as members, except in branches already covered by the existing membership. Bureaucratic control must be removed and research de-politicised, if it is to fulfil its purpose.

The broad functions of the Board, as I visualise, then should be :

(*a*) To plan national, scientific and industrial research in collaboration with the Industrial Research Utilisation Committee under the general direction of the parent council ;

(*b*) To develop facilities for the execution of the national research programme, by setting up national laboratories for chemical, metallurgical and physical, fuel, food and other types of research, stimulating the growth of private research, institutes and laboratories, introducing and encouraging the American fellowship plan in the country, etc., for this purpose ;

(*c*) To apportion research schemes to its own and private and university laboratories ;

(*d*) To control, supervise and co-ordinate scientific research activities as well as technological education in the country, thus ensuring proper collaboration between Government, industry and science ;

(*e*) To distribute grants to research institutes and individual research workers, when necessary ; and

(*f*) To formulate and submit its general recommendations annually to the parent council for approval.

The Board should continue to operate, as at present, through a number of research committees, each committee being in charge of research in a particular branch of science. Each branch should have a director, who may be attached to a particular institute, but should work as secretary of the research committee covering that particular branch,

so that the research committee on the one hand and the scientific institutes on the other may work in close collaboration under the general supervision and control of the Board.

To illustrate the general functions of these committees, I shall take the example of metallurgical research.

The metallurgical committee will collect statistics relating to the metallurgical possibilities of the country ; plan metallurgical research on the basis of these statistics under the general guidance of the Board ; assume responsibility for the design, construction, manning and supervision of a national metallurgical laboratory ; examine the suitability in practice of metallurgical schemes that may be referred to it by the Board for opinion or put up by universities or individual scientists.

The committee should also gather and possess information about the various laboratory facilities available for metallurgical research in the country, the type of research work already in progress, and the qualifications of various research workers ; and on the basis of this information, apportion research schemes to different laboratories and scientific societies, and provide the necessary funds for the prosecution of research.

The other committees will function along similar lines in their respective branches of research.

The Industrial Research Utilisation Committee should consist largely of industrialists and economists under the chairmanship of a non-official industrialist. The Director of Commercial Statistics and Intelligence and the Economic Adviser to the Government of India should collaborate as members of the Committee.

I think the Committee should be more than a mere research utilisation committee. It should be a proper Industrial Committee with much wider functions. It should co-operate with the Board in the formulation of a national research programme suited to the industrial resources and the economic conditions of the country, under the general direction of the parent council, the Research Utilisation Committee furnishing the industrial basis and the Board the scientific basis for the programme ; devise methods for the industrial and commercial utilisation of researches completed by the Board ; and formulate rules concerning the taking of patents and collection and distribution of royalties to facilitate the utilisation of scientific researches by industry.

This Committee will also operate through a chain of industrial committees, which, like the research committees, will cover the different groups of industries, collect industrial data, and advise on various industrial problems, both old and new.

The Board of Scientific and Industrial Research should also make its own laboratory facilities available to duly qualified workers and allow industries to have their own research workers employed in these laboratories to conduct research on specific problems on the lines of the American Research Associate Plan.

THE RÔLE OF SCIENCE ITSELF

At present, there is no proper co-ordination between the existing scientific institutes in the country, so that there is every possibility of unnecessary duplication of work and waste of scientific energy. I think there should be a supreme academy of sciences, as in the U. S. S. R., composed of representatives of private research associations and academies and eminent scientists drawn from the ranks of university science professors and lecturers.

Such an academy should collaborate with the Board of Scientific and Industrial Research in the general planning and direction of scientific research in the country, and also, provide, the Board with some of its new members and act as a link between it and the various scientific societies.

THE RÔLE OF THE UNIVERSITIES

I am aware that most of the Indian Universities today provide for the teaching of mechanical and electrical engineering courses, and the Benares Hindu University includes mining and metallurgy also, and the School of Mines at Dhanbad provides special facilities for education in mining and geology. But the teaching of science in our universities is not properly related to the needs of industry and is, in consequence, more academic and less practical. It is limited in scope and does not cover, or inadequately covers, many of the new branches of engineering essential to industry. Besides, science does not attract a sufficient number of students to meet the requirements of the country.

The first essential appears to be that the Universities should be provided with funds by the Board of Scientific and Industrial Research and the public, in order to enable them to add to their science curricula, improve their laboratory facilities and engage additional staff, wherever necessary.

The same Board should also provide sufficient scholarships for post-graduate research, so that it may be possible to utilise the growing reservoir of graduates possessing a natural aptitude for research, for intensive training in the methods of research, thus assuring industry of a growing supply of trained scientists.

It is further suggested that the last stages of education of science students should include a study of subjects like economics, law, and sociology in general, so that they may be able to wield not only scientific or technical posts in later life, but also administrative posts, requiring qualities of leadership and general business ability.

Also, the Universities should give facilities to industries to set up university fellowships for the purpose of investigations into specific problems of practical interest to industries and arrange with industrial companies and the railways for the practical training of its science students in factories and workshops during vacations.

Another type of education on which inadequate stress has been laid in the past is technological training. Facilities for such training should be provided on an adequate scale under the aegis of the provincial departments of industries, as a necessary preliminary to practical training in a workshop.

I have talked so far on technological training and on scientific education at the university stage. I think it is most essential for the future progress of the country that such education should begin early at school. "Pioneer Houses" or Children's Clubs on the Russian model, with science laboratories, should be set up to give a scientific bias to education right from the start. Problems of every-day science presented in simple language and followed by simple practical demonstrations in the classroom or in the laboratory, would, I am sure, not only prove useful to children in later life but also of absorbing interest to them in the immediate present.

If a proper scientific outlook is initially developed in the school stage and finished off in the university stage, we shall be assured of a regular

stream of scientific leaders not only for the universities but also for other research organisations in the country.

THE RÔLE OF INDUSTRY

If it has not been possible for Government to promote industrial development on a scale commensurate with the needs of the country, we must look to private enterprise more and more to fill the gaps in our industrial structure.

This can be accomplished only through research. Relatively large companies can set up research laboratories of their own, as the Tata Iron & Steel Company has done at Jamshedpur. Smaller concerns can form trade associations in particular fields of industry as in England and America, and set up common laboratories of their own for co-operative research for their mutual benefit.

Also, there is no reason why industry should not introduce and stimulate the growth of an industrial fellowship plan on the American model.

To my mind, the fellowship plan holds vast possibilities. It will encourage the universities to become more and more practical, add new science courses to their curricula, improve their science laboratories and staff, so that they may be able to cope with the growing demand for industrial research. It will benefit industry also by bringing the universities to its aid. Industrial concerns unable to afford the expenses of private laboratories of their own will be able to avail of research facilities at the universities at a relatively small cost.

Besides, the plan will enable promising scientists to get established in life and encourage youth to take up science in the future in much larger numbers than at present.

Financial considerations should not be allowed to prevent the expansion of research facilities at the universities, if the fellowship plan is to be a success. Government, industry and private individual should be able to provide the necessary funds for this purpose.

It will be agreed that research can be of little value unless its results find practical application. This brings the average factory worker into the picture. Means must be devised to educate him in the relatively elementary principles of science so that he may be in a position to apply the results of research to the working processes of industry. He cannot be expected to join a technological institute or college on a whole-time basis, nor has he the necessary equipment for university training. He must stay at his work in order to earn his living and yet receive his education in science. The answer appears to be part-time evening technical instruction at a technical night school, or, as some would prefer, part-time day instruction with evenings devoted to independent study of a wider nature under careful guidance. There is no reason why part-time technical schools close to industrial workshops should not be set up in all industrial areas. It is a necessary step to ensure the day-to-day application of research to industry.

THE EXISTING SCIENTIFIC SERVICES

It will be generally agreed that the existing Government scientific services, like the Geological Survey and the Botanical Survey, are inadequately staffed. The first necessity in this connection is to increase their strength substantially so that they can prove equal to the varied problems that the India of today presents.

There is another question that arises in this connection. What place should be assigned to these scientific services in the Government Department of Scientific and Industrial Research?

The question bristles with controversy. Yet I feel the two should not be divorced. The services may be given the largest possible measure of autonomy, but they should co-operate with the Government Department of Scientific and Industrial Research in the enunciation of policy, and be guided by it. This will enable the broader outlook of the department to be brought to bear on purely sectional considerations. It is not my intention, however, to be too dogmatic in this connection. The matter can bear further consideration at a later date.

PRESS AND PUBLICITY

Research, pure or applied, cannot be said to fulfil its purpose, unless its results are interpreted to the community. At present, such results are published in the form of articles and reports only in a limited number of technical periodicals. The daily press, which reaches the masses and moulds public opinion crams its columns largely with sports news and sensational events, devoting little space to scientific intelligence. If a scientific article does happen to be included, it is, as a rule, not properly edited, as most editors are non-scientific men who have confined themselves to arts studies.

In the future, in order to make the public science-conscious and create the correct environment for the development of scientific research, it will be essential to use the daily press more and more as an organ for the dissemination of scientific knowledge. The technical articles will have to be written in terse and lucid prose employing rhetoric, if necessary, to appeal to the popular mind. The editorial staff of the papers will have to include scientists, to ensure proper editing of these articles.

Also, there should be a Scientific News Agency, just as we have "Reuters" for general news, and its function should be to provide scientific news in readable language for publication in the daily press for the benefit both of grown-ups and children. The subject matter and style should be adapted to the needs of children, if it is for the "Children's Corner" ; for adults, it may be a little advanced, but, in no case, above the head of the man-in-the-street.

In addition to the printed word, we should utilise exhibitions, the film and the radio as media of popular publicity. In fact, no possible medium should be left unexploited.

SUMMARY AND CONCLUSION

To summarise my proposals: The existing Board of Scientific and Industrial Research should be retained, but its membership should include a larger number of scientists than at present, so as to cover all branches of science, and the functions of the constituent bodies of the department should be slightly re-classified to prevent over-lapping. The official scientific services should be autonomous in their daily operation, but should co-operate with the above-mentioned department of research. A supreme National Academy of Sciences representing the existing scientific societies should be brought into existence to co-ordinate the work of the various scientific societies and co-operate with the Board of Scientific and Industrial Research in general scientific direction. Provision has also been made for bringing industry into contact with science, and

both, into contact with Government, and some indication given of the media of publicity that can be usefully exploited.

Many years ago, Andrew W. Mellon wrote: "It is science, not Government, nor wars of conquest that opens to us new horizons". Never were these words so true as today. It is research, and nothing else, that can develop our industries and improve our agriculture. It is research, and nothing else, that can bring us wealth and prosperity in this age of competitive efficiency. Today, research is progress, research is life.

Proceedings of the Thirty-first Indian Science Congress

PART III—ABSTRACTS

CONTENTS

SECTION OF MATHEMATICS AND STATISTICS

President:—B. M. Sen, M.A., F.N.I., I.E.S. (Retd.).

1. On the differentiability of step functions.

P. D. Shukla, Lucknow.

The object of this paper is to answer the following question:

Does the existence of $\phi'(0)$ for a step function $\phi(x)$ depend upon the existence of the metric density at $x = 0$ of the set of values of x corresponding to the lines of invariabilty of $\phi(x)$?

It has been shown that the answer to this question is in the negative.

2. On the differential equation of two dimensional viscous flow.

B. R. Seth, Delhi.

The solution of the differential equation of two dimensional viscous flow of a liquid is discussed in the two forms

$$\sum_0^\infty r^{-n}\phi_n(\theta) \quad \text{and} \quad \sum_0^\infty \theta^n f_n(r).$$

It is also shown how the latter of the two solutions may be adapted to get any desired degree of accuracy for the problem of a circular cylinder moving with a uniform velocity through a viscous liquid.

3. Multi-stage sampling.

P. C. Mahalanobis, Calcutta.

A technique of large scale sample survey in which the area under investigation is divided into a number of zones from each of which a suitable number of sampling units are selected at random (for observation or treatment) was found by the author to be appropriate for a certain type of enquiry (e.g. the census of acreage under a particular crop). The corresponding theory was developed in certain memoirs and also discussed at previous sessions of the Science Congress. For other types of enquiry (e.g. estimate of the total yield of a particular crop) this procedure would be extremely expensive and a different technique has to be adopted. The whole area under investigation is divided into a number of zones (say K) each of which is cut up into a number of units N_1, each of which again into a number of sub-units N_2 each of which again is divided into a number of smaller sub-units N_3 and so on till we get to the last stage. This is the population to be sampled. From each zone a number of units n_1 is selected at random from each of which again a number of sub-units n_2 are selected from each of which again a number of smaller sub-units n_3 are selected and so on till we get the last stage where we have actual observations in terms of which the total quantity under investigation has to be estimated. The process of selection at each stage is random. This technique has been called one of multi-stage sampling. An estimate of the total quantity or value under investigation (e.g. yield of crop) has been worked out in terms of the last stage observations and variance of this estimate has also been obtained. Subject to a given cost level and certain simple types of cost function (which, however, take into account

the journey cost) the best design (one leading to minimum variance) has been worked out giving the appropriate choice of n_1, n_2, etc. at different stages of this multi-stage sampling.

4. On the distribution of the correlation coefficient when the variables are independent and one of them follows the normal distribution.

C. CHANDRA SEKAR *and* S. C. BHOUMIK, Calcutta.

The distribution of the correlation coefficient when the two variables are independent and one of them follows the normal law has been worked out and is found to be the same as that given by Fisher when both the variables are drawn from independent normal populations.

5. Distribution of the correlation coefficient for samples of three when the variables are independent.

C. CHANDRA SEKAR *and* S. C. BHOUMIK, Calcutta.

A method to assist in working out the distribution of the correlation coefficient for samples of three when the populations are independent is suggested and is illustrated in getting its distribution: (i) when the two populations follow the continuous rectangular law; (ii) when both follow the normal law; (iii) when one follows the rectangular and the other the normal law.

It is shown that the distribution of the correlation coefficient, for samples of three, is independent of the form of the other population if one follows the normal law.

The distribution of the correlation coefficient, whatever be the populations, is such that the chance of its lying in the three intervals -1 to $-\frac{1}{2}$, $-\frac{1}{2}$ to $\frac{1}{2}$ and $\frac{1}{2}$ to 1 is each equal to $\frac{1}{3}$.

6. An asymptotic expansion.

K. SANKARA PILLAI, Trivandrum.

In this paper, a method to obtain the dominant term corresponding to the nature of a function at infinity is indicated. It will be observed that there are several methods of deducing the form of a function at infinity, but the determination of the absolute constant very often requires heavy mathematical analysis.

The asymptotic form of the function $f(x)$ defined by the power series $f(x) = \Sigma(x^n/n!)^3$ is studied in detail. The method of Steepest Descent gives the dominant term and the complete series is obtained by finding the differential equation satisfied by $f(x)$.

7. The fundamental theorem of linear estimation.

R. C. BOSE, Calcutta.

Given n stochastic variates $y_1, y_2, \ldots\ldots y_n$ whose expectations are linear functions of m parameters $(m \leqslant n)$, $p_1, p_2, \ldots\ldots p_m$

$$E(y_i) = a_{i1}p_1 + a_{i2}p_2 + \ldots\ldots + a_{im}p_m \qquad (i = 1, 2, \ldots\ldots n)$$

and which have a common variance σ^2, there arises the problem of finding the best unbiassed linear estimate of the parametric function

$$P = l_1p_1 + l_2p_2 + \ldots\ldots + l_np_n$$

i.e. the problem of finding a linear function

$$Y = c_1y_1 + c_2y_2 + \ldots\ldots + c_ny_n$$

of the stochastic variates with minimum variance, whose expectation is P. When the matrix

$$A = ((a_{ij})) \qquad i = 1, 2, \ldots\ldots n; \; j = 1, 2, \ldots\ldots m$$

has the rank m, Markoff has shown, that the required estimate is obtained by minimizing

$$\sum (y_i - l_1 p_1 - l_2 p_2 - \ldots\ldots - l_m p_m)^2$$

with respect to the p's, and substituting the values so derived in P. He also gives an estimate of the variance σ^2. The following theorem however holds irrespective of the rank of A.

Theorem: If P is an estimable parametric function, there exists one and only one linear function of the variates Y, for which $E(Y) = P$ and for which the vector

$$\gamma = (c_1, c_2, \ldots\ldots c_n)$$

is of the form

$$\gamma = k_1\alpha_1 + k_2\alpha_2 + \ldots\ldots + k_m\alpha_m$$

where $\alpha_1, \alpha_2, \ldots\ldots \alpha_m$ are the column vectors of the matrix A. This linear function provides the best unbiassed linear estimate of P.

It has been shown in the paper, that in all important applications this theorem can be directly used, without any recourse to actual 'minimization'.

Representing n-vectors, by lines drawn through the origin in a Euclidean space of n-dimensions, the r-space of the vectors $\alpha_1, \alpha_2, \ldots\ldots \alpha_m$ ($r \leqslant m$ = rank of A) may be called the 'estimation space', and the space absolutely orthogonal to it may be termed the 'error space'. Our fundamental theorem then merely states that there is a (1, 1) correspondence between the estimable parametric functions P, and the vectors γ of the estimation space, such that $(\gamma . \eta) = c_1y_1 + c_2y_2 + \ldots + c_ny_n$ is the best unbiassed linear estimate of P. Various other interesting properties of the 'estimation' and the 'error spaces' have been proved. In particular the estimate of the common variance σ^2, is simply the square of the projection of the stochastic vector $\eta = (y_1, y_2, \ldots\ldots y_n)$ on the error space, divided by $n-r$. The actual value thus derived agrees with Markoff's result when $r = m$.

8. On the problem of balancing in symmetrical factorial designs.

R. C. Bose, Calcutta.

In an s^m symmetrical factorial experiment with m factors each at $s = p^n$ levels, every treatment combination can be represented by a point $(x_1, x_2, \ldots x_m)$ of the Finite Geometry $EG\ (m, p^n)$, if the p^n levels be identified with the p^n elements of the Galois Field $GF\ (p^n)$. It has then been shown in a previous paper (R. C. Bose and K. Kishen: On the problem of confounding in General Symmetrical Factorial Design. *Sankhya*, Vol. 5, pp. 21–36) that the comparisons between the $(m-1)$-flats of any parallel pencil carry $(s-1)$ degrees of freedom. All the $\frac{(s^m-1)}{(s-1)}$ orthogonal sets of $(s-1)$ degrees of freedom are thus accounted for, and a complete enumeration of the various possibilities of confounding can be made. These results have been applied in the present paper to the problem of obtaining balanced sets of confounded symmetrical designs. This problem has been previously studied for designs of the type 4^m and 5^m by K. R. Nair in two papers in the *Sankhya* (Vol. 4, 1938, pp. 121–138, Vol. 5, 1940, pp. 57–70). His method depending on the use of orthogonal Latin squares works only when $(s-1)$ is also a prime power. The use of Finite Geometry and Algebra, dispenses with this restriction, and opens

out various new possibilities. For example, in the case of any s^4 design with s^2 plot blocks, consider the design for which the treatment combinations falling in the same block, satisfy the simultaneous linear equations

$$x_1+\alpha x_3+\beta x_4 = l_1$$
$$x_2+c\beta^{-1}x_3+d\alpha^{-1}x_4 = l_2$$

where $c \neq 0$, $d \neq 0$, $c \neq d$, and the different blocks are obtained by giving the constants l_1, l_2 all possible values in $GF(p^n)$. The $(s-1)^2$ designs obtained by giving α, β all possible non-null values in $GF(p^n)$ then form a set for which the second order interactions are balanced. This set may be called the set (c, d). Giving c, d various non-null values, we get different balanced sets. A suitable combination of $(s-1)$ of the sets (c, d) when s is even, and $\frac{(s-1)}{2}$ of the sets (c, d) when s is odd, leads to a complete balance for the 3rd order interactions also.

9. Bernoulli's theorem, and its analogue deduced from Tshebycheff's theorem.

S. N. Roy *and* P. K. Bose, Calcutta.

Bernoulli's theorem on the probability that in a series of n trials (where the chance of success is constant from trial to trial and equals p), the number of successes m should be within a certain range of the expectation value, can be stated as

$$P\left\{\left|\frac{m}{n}-p\right|<\epsilon\right\} > 1-\eta \text{ if } n \geqslant n_0(\epsilon, \eta) \quad .. \quad .. \quad (1)$$

where ϵ and η are arbitrary small numbers and

$$n_0(\epsilon, \eta) \equiv \frac{1}{\epsilon}+\frac{1+\epsilon}{\epsilon^2}\log\frac{1}{\eta} \quad .. \quad .. \quad .. \quad (1.1)$$

We can obtain a corresponding theorem as a special case of Tshebycheff's formula by introducing n stochastic variables $x_1, x_2, \ldots\ldots x_n$ each of which can take values 1 or 0 with chances p or q. This theorem comes out as

$$P\left\{\left|\frac{m}{n}-p\right|<\epsilon\right\} > 1-\eta \text{ if } n > n_0'(\epsilon, \eta) \quad .. \quad (2)$$

where
$$n_0'(\epsilon, \eta) = \frac{1}{4\eta\epsilon^2} \quad .. \quad .. \quad .. \quad .. \quad (2.1)$$

Both (1) and (2) being inequality relations the question naturally arises as to which of (1.1) or (2.1) gives a closer limit, that is, which of $n_0(\epsilon, \eta)$ or $n_0'(\epsilon, \eta)$ is smaller. The ranges for ϵ, η in which we are interested for purposes of this question are evidently $\epsilon \to 0$ to 1 and $\eta \to 0$ to 1. The question was tackled by numerical-cum-graphical methods and it was found that on the (ϵ, η) plane and within the square ($\epsilon \to 0$ to 1 and $\eta \to 0$ to 1) for a certain range including the origin Bernoulli's theorem gives a closer limit while in the rest of the square Tshebycheff gives a closer limit. But we are more interested in the neighbourhood of the origin, that is, for small values of (ϵ, η); hence Bernoulli's theorem gives us the closer limit within the range of practical interest. It is well known that Bernoulli's proof of his theorem (1) is long and tedious compared with the proof of Tshebycheff's theorem and of its special case (2) which gives an analogue of Bernoulli's theorem. The above investigation shows that the extra labour involved in Bernoulli's proof of his theorem (1) is well justified in as much as it gives a much closer limit than the analogous theorem (2) which can be proved much more easily.

10. Multi-variate analysis of variance when the number of populations is less than or equal to the number of characters.

S. N. Roy, Calcutta.

The problem of p-variate analysis of variance can be regarded as one of testing in the light of sample readings the hypothesis that for k, p-variate normal populations with a common dispersion matrix $\| \alpha_{ij} \|$, $m_{i1} = m_{i2} = \ldots = m_{ik}$ $(i = 1, 2, \ldots p)$ where m_{il} refers to the mean of the i-th character for the l-th population and $l = 1, 2 \ldots k$. For the case of $k > p$ this problem was tackled in 1939 by Fisher, Hsu and the author who introduced an appropriate set of p-statistics and obtained their joint sampling distribution in the null hypothesis

$$m_{i1} = m_{i2} = \ldots = m_{ik} \qquad (i = 1, 2 \ldots . p).$$

The author obtained in 1940-41 and published in full in 1942 the joint sampling distribution of these statistics and also of some of their symmetric functions in 1942. The separate distributions of these statistics and in particular of the statistics which are numerically maximum and minimum were also worked out in 1942-43.

The present paper solves the corresponding problem for the case $k \leq p$ where we have in general $(k-1)$ statistics instead of p-statistics. This problem was considered some time ago by Hsu and others and a partial solution was given. The present paper attempts to give the complete and general solution of the problem of joint and individual distributions both for the null as well as for the non-null hypothesis.

11. The recovery of inter-block information in incomplete block designs.

K. R. Nair, Calcutta.

In agricultural field experiments, it has been found that, unless the field is very heterogeneous, the adoption of incomplete block designs leads to inefficient estimates of treatment differences, if the whole of the apparent block differences is eliminated from such estimates. When the block differences are not high, the efficiency of the estimates of treatment differences can be improved by pooling the intra-block and inter-block information. The process of doing this has been worked out in this paper for partially balanced incomplete block designs, of which the quasi-factorial and confounded designs are special cases. The situation when some plots of these designs are missing has also been dealt with.

12. The impossibility of the symmetrical balanced incomplete block design $k=7, \lambda=2$.

Q. M. Hussain, Dacca.

The paper gives a method of obtaining a balanced incomplete block design direct from its definition. The method consists in filling up any one block with treatments 1, 2, 3 .... etc., as many as there are plots in a block and then arranging these treatments in the other blocks fulfilling the conditions of such a design. A second block is filled up with the necessary number of new treatments and the above procedure is repeated and so on. It must yield a solution if it exists at all and, over and above, all possible non-isomorphic solutions can be enumerated. By this method it has been found that the design: (I) $v = b = 22$, $r = k = 7$, $\lambda = 2$ has no solution; (II) $v = b = 11$, $r = k = 5$, $\lambda = 2$ has only one non-isomorphic solution; and (III) $v = b = 16$, $r = k = 6$, $\lambda = 2$ has three non-isomorphic solutions only.

13. Note on the enumeration of all possible non-isomorphic solutions of balanced incomplete block designs.

H. K. NANDI, Calcutta.

Mr. Q. M. Hussain in a paper to be published in a forthcoming issue of the *Sankhya* gives a method for the enumeration of all possible non-isomorphic solutions of balanced incomplete block designs. He has tried this method on the symmetrical designs only ($v = b$, $r = k$, λ) and has shown the impossibility of the design: (I) $v = b = 22$, $r = k = 7$, $\lambda = 2$ and also that (II) $v = b = 11$, $r = k = 5$, $\lambda = 2$ has only one non-isomorphic solution while the design: (III) $v = b = 16$, $r = k = 6$, $\lambda = 2$ has three non-isomorphic solutions only. In the present note the same method has been applied to the corresponding unsymmetrical designs obtained by block section (i.e. omitting one block and all the treatments belonging to it). It has been found that the design: $v = 6$, $b = 10$, $r = 5$, $k = 3$, $\lambda = 2$ obtained from (I) by block section has also only one non-isomorphic solution while the design $v = 10$, $b = 15$, $r = 6$, $k = 4$, $\lambda = 2$ obtained from (II) has six non-isomorphic solutions. The latter result in conjunction with (II) leads to the conclusion that the reverse process of block section, when applied to different unsymmetrical designs, may lead to the same symmetrical design.

14. On Stirling's approximation based on Fourier transform.

(MISS) A. GEORGE, Trivandrum.

In this paper, a method of proving the Asymptotic form of $\Gamma(x)$ for large x is given. Consider a stochastic variable z following the law

$$\left[\frac{x^x}{\Gamma(x)}\right] z^{x-1} e^{-xz} \qquad 0 \leq z$$

Then the characteristic function of the distribution is

$$\phi(t) = \frac{x^x}{(x-it)^x} = \frac{1}{\left(1-\dfrac{it}{x}\right)^x}.$$

For large values of x, we write

$$\phi(t) \sim e^{it-\frac{t^2}{2x}}\left[1+O\left(\frac{1}{x^2}\right)\right]$$

Hence by Fourier transform

$$p(z) \sim \left[\frac{x}{2\pi}\right]^{\frac{1}{2}} e^{\frac{-x(z-1)^2}{2}}.$$

Thus
$$\left[\frac{x^x}{\Gamma(x)}\right] z^{x-1} e^{-xz} \sim \left[\frac{x}{2\pi}\right]^{\frac{1}{2}} e^{\frac{-(z-1)^2 x}{2}}$$

Since the two functions in the above equation tend to become zero as $x \to \infty$ for every value of z ($\neq 1$), we get

$$\frac{(2\pi)^{\frac{1}{2}} x^{x-\frac{1}{2}}}{\Gamma(x)} \sim \left|\frac{e^{-x(z-1)^2/2}}{z^{x-1}e^{-xz}}\right|_{z=1} = e^x$$

i.e.
$$\Gamma(x) \sim (2\pi)^{\frac{1}{2}} x^{x-\frac{1}{2}} e^{-x}$$

It may be noted that limiting forms of distribution functions as the one considered above give convenient Dirac functions.

15. On the arithmetic and the geometric means from a type III population.

S. Janardana Aiyer, Trivandrum.

The present paper is based on the simultaneous sampling distribution of the arithmetic mean, $\bar{X}$, and the geometric mean, g, in samples of size n from a type III population defined by

$$P(X) = \frac{m^p X^{p-1} e^{-mx}}{\Gamma(p)}. \qquad 0 \leq X$$

The following results are established.

1. $$P(\bar{X}, g) = \frac{e^{nP - \frac{1}{12nP}} (mn^2)^{nP}}{2\pi\sqrt{\dfrac{P\psi'(P)-1}{2P}}} \frac{\bar{X}^{nP-1}}{g} e^{-mn\bar{X}-n} \times$$

$$\frac{\left[\psi(P) + \dfrac{1}{2nP} + \log\dfrac{n^2\bar{X}P}{g}\right]^2}{2\left[\dfrac{P\psi'(P)-1}{P}\right]} \left[1 + O\left(\frac{1}{n^2}\right)\right]$$

2. If $\mu_{r.t}$ = the mathematical expectation of $\bar{X}^r g^t$, then

(*a*) $$\mu_{r.t} = \frac{(nP+t)(nP+t+1)\ldots(nP+t+r-1)}{n^r \cdot m^{r+t}} \frac{\Gamma^n\left(P + \dfrac{t}{n}\right)}{\Gamma^n(P)}$$

(*b*) The β coefficients of g and the correlation coefficient between $\bar{X}$ and g are determined. Their asymptotic behaviour has also been studied.

3. (*a*) The regression of $\bar{X}$ on g has been established; but it takes a very complicated form. Even in the simple cases when $n = 2$, or $n = 3$, the expression for $\bar{X}_g$ is by no means elementary.

(*b*) The regression of g on $\bar{X}$ is linear and is given by

$$g_{\bar{X}} = \Gamma^n\left[\frac{p+1}{n}\right] \frac{\bar{X}}{p\Gamma^n(p)}.$$

It is interesting to point out in this connection, that even though the distribution of g and $\bar{X}$ is definitely non-normal, the same linear regression equation for g on $\bar{X}$ is obtained by fitting a polynomial regression equation, the constants being determined by the method of least squares.

16. Confidence interval for the correlation coefficient.

K. C. Sreedharan Pillai, Trivandrum.

The object of this paper is to study the power function of the Correlation Coefficient defined by Neyman-Pearson, corresponding to the critical regions based on—

(1) Dr. U. S. Nair's Probability statements regarding the ratio of Standard Deviations and Correlation Coefficient in a Bivariate Normal Population,
(2) Fisher's Z'-transformation,
(3) Miss A. George's Shortest Confidence Interval method.

The first of these methods gives a purely theoretical approach for testing the hypothesis $\rho = \rho_0$, without the direct application of the exact

distribution of r which is highly complicated. Fisher's Z'-transformation is made use of, with advantage, to get the confidence limits of r and it is found from the examples worked out that the limits obtained by the two methods evince very little difference. With the help of the Tables of the Correlation Coefficient by Miss David the shortest confidence intervals for r have also been obtained. But this test shows more bias than the other two. However, as the sample size increases the bias begins to disappear.

17. On the construction of bivariate distribution functions satisfying the condition of zero-correlation.

K. C. SREEDHARAN PILLAI, Trivandrum.

In this paper it is proposed to discuss a general method of constructing distribution functions satisfying the condition of zero-correlation, the variates being not independent.

Consider two variates x and y, and let

$$p_i(x) \text{ and } q_i(y) \qquad (i = 1, 2, 3, \ldots, n) \qquad \ldots \quad (1)$$

be sets of probability functions, such that

$$\int p_i(x)\, dx = 1$$

$$\int q_i(y)\, dy = 1$$

the integrals being taken over the domains for which (1) is defined.

Let

$$P(x,y) = \sum_1^n A_i p_i(x) q_i(y) \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

where $\sum_1^n A_i = 1$, **the A's being positive** $\ldots \quad \ldots \quad \ldots \quad \ldots \quad (3)$

Then the A's in (2) are adjusted to satisfy

$$\left.\begin{array}{l} E(x,\ y) = E(x)\,.\,E(y) \\ \text{which implies that correlation between } x \text{ and } y \text{ is zero.} \\ \text{Clearly } P(x,y) \neq P(x)\,.\,P(y) \text{ in general.} \end{array}\right\} \quad \ldots \quad \ldots \quad (4)$$

If $\bar{x}_i$ and $\bar{y}_i$ are the means of x_i and y_i, the first condition in (4) gives

$$\sum_1^n A_i \bar{x}_i \,.\, \bar{y}_i = \left[\sum_1^n A_i \bar{x}_i\right]\left[\sum_1^n A_i \bar{y}_i\right] \quad \ldots \quad \ldots \quad (5)$$

(3) and (5) lead to the construction of distribution functions satisfying (4).

The method is illustrated by examples of distribution functions consisting of two, three and four components. The regression curves in each case are also determined.

18. Generalized variance of populations.

C. RADHAKRISHNA RAO, Calcutta.

In the paper 'The perimeter test in the problem of classification' which formed a part of the thesis submitted to the Calcutta University, a generalized measure of divergence, with respect to the means of the characters, among k populations is given. The sample estimates of this measure both in the classical and the studentized forms are used in tests of significance. In the studentized form the variances and covariances of the several characters are all stochastic variables and may be called the generalized variance of the *first kind*. New situations arise where the

variances and covariances are each a constant times a stochastic variable. The generalized variance formed with these may be said to be of the *second kind*. This is useful in tests of significance and classification of several regression surfaces, etc. Incidentally, we get generalized distance (Mahalanobis) of the second kind. The necessary distributions have been derived.

19. Quasi-latin squares in experimental arrangements.

C. RADHAKRISHNA RAO, Calcutta.

In the thesis submitted by the author, in 1943, to the Calcutta University, it was shown how the design of experiments consists of the fundamental problem together with the problem of balancing and the construction of designs. Every experimental design is a mathematical solution to a combinatorial problem directly deducible from the mathematical model set up by the necessary balance, block size, number of replications, etc. These problems are dealt with, in detail, in the case of incomplete block designs. These ideas are extended to quasi-latin square arrangements and two fundamental types each giving two sub-types of designs similar to the partially balanced and the intra- and inter-group balanced designs have been discovered. Double confounding in factorial experiments comes out as a special case.

20. On certain transformations in generalized hypergeometric series.

B. N. BOSE, Dacca.

The object of the note is to obtain various expansions involving hypergeometric functions and to extend Kummer's theorem. It has been shown that ${}_2F_1[a, b; 1-x+a-b; -1]$ is always expressible in a finite series, if x be an integer, positive or negative.

21. Some studies in Mahalanobis's correlation function.

BIRENDRANATH GHOSH, Calcutta.

Prof. Mahalanobis has introduced the conception of correlation function, for dealing with the problems of sample surveys, especially for non-random or patterned fields. In this paper it has been attempted to construct fields—both algebraic and stochastic (and their combinations as well)—to follow given forms for the correlation function. Fields have been constructed and discussed for ρ equal to 0, 1, negative or when it is generally periodic or pure simple harmonic. Some fields have also been constructed which follow Mahalanobis's specifications for 'natural' fields, namely ρ is positive and gradually tends to zero as the interval increases. In this connection it has been pointed out that there are two physically distinct types of correlation function, inter-class and intra-class; the inter-relations between these two types have been discussed and illustrated with simple fields.

The generalizations to the N-dimensional fields are easy and have been indicated.

SECTION OF .PHYSICS

President:—D. S. KOTHARI, PH.D. (CANTAB.), F.N.I.

Mechanics and General Properties of Matter

1. A note on exudation phenomenon.

A. G. CHOWDHURY, Delhi.

Observations have been taken under different conditions of the phenomenon of exudation and its relation with the phenomenon of tears of wine has been discussed.

2. An optical extensometer for the determination of elastic constants.

K. R. CHAUDHARI *and* D. V. GOGATE, Baroda.

A simple method based on the lateral shift of an image by a refracting glass cube is described for the determination of Young's modulus, rigidity and Poisson's ratio of various materials.

The apparatus consists mainly of a travelling microscope reading up to 0·002 cm. and an optically true glass cube mounted on a drum which is rigidly fixed to a frictionless wheel, the latter being free to rotate about the axis of the drum. The values of elastic constants obtained by using this simple extensometer are found to be in excellent agreement with the usually accepted experimental values. The extensometer is also used for measuring the linear coefficient of expansion of different materials and is found to give satisfactory results.

3. Reynold's number and liquid helium II.

D. V. GOGATE, Baroda.

The peculiar properties of liquid helium below the λ-point, viz. a discontinuity in its specific heat, a decrease in its viscosity, the thermo-mechanical effect, etc. which have been discovered in recent years, have not received a satisfactory theoretical explanation so far. The flow of liquid helium II appears to be remarkable because it is almost independent of pressure.

In this paper the three types of flow, viz. Poiseuille's flow, turbulent flow and liquid helium flow, are discussed from the dimensional point of view. It is found that these three types of flow can be represented by the general relation $V = Ap^n$, where V is the volume rate of flow through a capillary under a pressure difference p, A is a constant and n is equal to 1, $\frac{1}{2}$ and zero respectively for the three types of flow. It is then shown that on dimensional considerations the Reynold's number $u\rho D/\eta$ must remain constant in the case of liquid helium flow, the constant depending, of course, on temperature. Also the velocity of flow will be inversely proportional to the diameter of the capillary tube and the volume rate of flow will vary as the first power of the radius of the tube.

Heat and Thermodynamics

4. The kinetic theory of rubber.

F. C. AULUCK *and* D. S. KOTHARI, Delhi.

The (isothermal) Young's modulus of *ideal* rubber is determined by statistical methods. The macrostate of a chain-molecule is here defined in terms of its length and not in terms of the distance between the ends of the chain. Section 1 deals with thermodynamical results holding for ideal rubber and in section 2 the treatment based on ends-separation of the molecule-chain is described. Section 3 treats the problem on the basis of the length of the molecule-chain.

5. Energy spectrum for 'holes' in a liquid.

F. C. AULUCK *and* D. S. KOTHARI, Delhi.

In some of the recent theoretical studies on the liquid state, a liquid has been represented as a continuous medium permeated with 'holes'. For the holes-model of a liquid, it is important to construct formally the Schrödinger equation for a hole and determine its energy. The energy is given by

$$E_n = 6{\cdot}6 \times 10^{-15} \frac{\sigma^{\frac{5}{7}}}{\rho^{\frac{2}{7}}} \left(n + \frac{7}{10}\right)^{\frac{4}{7}}$$

where n is an integer including zero, σ denotes the surface tension of the substance and ρ is the density. The 'classical radius r' for a hole in the ground state is found by writing $E_0 = 4\pi r^2 \sigma$ which for liquid helium gives about four times the classical radius of the helium atom. The discrete energy spectrum of the holes may reveal its presence in scattering and ultra-sonic phenomena.

6. Boiling point temperature and the viscosity of a gas.

A. K. DATTA, Delhi.

The viscosity of gases were found to be represented by an equation of the form

$$\eta = A T^{\frac{1}{2}} \exp. \left\{ -\left(\frac{T_B}{T}\right)^{\frac{1}{2}} \right\}$$

or

$$\frac{\eta}{\eta_B} = x \exp. \left(1 - \frac{1}{x}\right)$$

where $x = \left(\frac{T}{T_B}\right)^{\frac{1}{2}}$, T_B is the boiling point temperature and η_B is the viscosity of the gas at that temperature. The relationship was fixed and found to hold good for air, A, H_2N_2, O_2, CO, CO_2 as well as vapours like C_6H_6, CS_2, $CHCl_3$, CCl_4, etc. throughout the range of temperature where viscosity measurements are available. The second equation gives us a universal curve to determine the viscosity of any gas or vapour at any temperature when its boiling point temperature and the viscosity at any temperature is known.

7. Liquid state and Bose-Einstein condensation.

R. N. RAI *and* D. S. KOTHARI, Delhi.

The theory of the liquid state has been the subject of numerous investigations during recent years. Fürth has considered a model where the liquid is assumed to be a continuous medium permeated with 'holes'.

In view of the suggestion of London that liquid He II represents matter in the state of Bose-Einstein degeneracy, it appeared worth while to extend Fürth's theory to the degenerate gas. Assuming that the number of holes cannot exceed the number of molecules present in the liquid it is found that the Bose-Einstein condensation will occur when the temperature is reduced below

$$T = \left[\frac{2^{\frac{15}{2}} 3^{\frac{1}{2}} N h^4 \sigma^{\frac{7}{2}}}{5\pi M \rho k^{\frac{11}{2}}}\right]^{\frac{2}{11}}$$

where σ is the surface tension, ρ the density and M the molecular weight of the liquid. For the case of liquid helium this gives for T the value 12·3°A. whereas the experimental value is 2·2°A.

Molecular, Atomic and Nuclear Physics

8. Measurement of the brightness of the zenith sky during twilight and an approximate estimate of the number of atomic transitions producing λ5577 in the atmosphere at night. Part III.

M. W. Chiplonkar *and* J. D. Ranade, Bombay.

In continuation of the previous work by the present authors further intensity measurements were carried out at Poona during the morning and evening twilights in the clear months (March and April) of 1943. As suggested in the previous communication we have used in the present measurements the two colour filters: (1) Green filter VG_1 (Schott and Genossen); (2) An auroral filter (a combination of three Schott and Genossen colour filters). This combination transmits a narrow spectral region of about 160 A.U. around the green auroral line λ5577. For every twilight two curves were drawn, one for each filter used, showing the variation of log $(1/r^2)$ against (θ), the depression of the sun below the horizon. For both the filters used, the zenith sky was on the average slightly brighter during evening than during morning twilight. Over the whole range of observation (i.e. $\theta = 4° 30'$ to 18° and more) it was found that the auroral filter curve always lay below the green filter curve. This difference at first increases with θ, reaches a maximum at about $\theta = 12°$-13° and again decreases, finally reaching a steady value beyond $\theta = 16°$. For the night conditions the average values of the ratio Green/Auroral intensity are 3·08 and 3·23 for the morning and the evening twilight respectively. Expressed in absolute units the average auroral intensity observed just before the beginning of morning twilight (θ greater than 18°) at Poona (1943) is $1{\cdot}269 \times 10^{-4}$ candles per sq. metre, which following Rayleigh's method represents about $5{\cdot}772 \times 10^{12}$ atomic transitions emitting λ5577 in the atmosphere per sec. per sq. metre. The corresponding value deduced by Rayleigh from his measurements on the night sky in England is $1{\cdot}81 \times 10^{12}$ atomic transitions per sec. per sq. metre.

9. On the range of tensor neutron-proton interaction.

Pritam Sen, Delhi.

The existence of tensor interaction from a descriptive picture of nuclear forces was predicted by Wigner in 1937 and has been used to explain the quadrupole moment of the deuteron. Rarita and Schwinger assumed the spherical and the tensor parts of the neutron-proton interaction to be rectangular wells of same range and found discrepancies in the magnetic moment of the deuteron and the photo-electric cross-section. The binding energies of H^3 and He^4 also have been found to be unsatisfactory. In this paper the effect of the variation of the range of the tensor

interaction is considered. For mathematical simplicity and as expected from the field theory the range of tensor interaction is taken less than that of the spherical part of the neutron-proton interaction. And we tried to get the best agreement for the magnetic moment of the deuteron. It is found the agreement is best when the ranges are equal, i.e. as in Rarita and Schwinger's approximation. Then using an error potential corresponding to the rectangular well potential the binding energies of He^4, Li^6 and O^{16} are found in the central field approximation and the results indicate the non-saturative character of the tensor forces, as already pointed out by Volkoff for heavy nuclei.

10. Seasonal variation in the radon content of Trivandrum spring water.

A. O. Mathai, Trivandrum.

A new type of emanation electroscope is described with which the radon content of a spring in Trivandrum was studied monthly for one year. The activity of the source was found to remain practically steady throughout this period independent of the rate of flow of water. The average radon content of the spring is $8{\cdot}49 \times 10^{-10}$ Curies per litre which is only a 100th of that detected by the Rev. A. Steichen for the hot springs of Tuwa in Bombay. The behaviour of the spring is compared with the seasonal variations observed in the case of other springs and the probable nature of the distribution of radium in the laterite formation from which the spring originates is discussed.

11. Radioactivity of Warkala waters.

A. O. Mathai, Trivandrum.

The famous freshwater springs of Warkala in Travancore have been examined for their radioactivity using an emanation electroscope. While the average radium content of the spring has got only a very low value of the order of 10^{-10} Curies per litre, that of one among them, which is most reputed, is nearly ten times this value. Judged side by side with similar observations made over continental Europe, it is shown that there is reason to believe that at least to some extent the therapeutic value of the spring is due to its radioactive contents. No trace of dissolved radium was detected in any of the specimens collected from the locality.

12. Estimation of radium in the monazite sand and rocks of Travancore.

A. O. Mathai, Trivandrum.

The radium content of monazite sand and certain igneous rocks of Travancore has been estimated by the solution method using an emanation Gold Leaf Electroscope constructed by the author and standardized by using a standard solution of radium bromide. The average radium content of monazite sand is $12{\cdot}32 \times 10^{-10}$ gm./gm. which is of the same order as that present in the Brazilian mineral. The average value obtained for the three types of granites examined, including that obtained from the Western Ghats is $2{\cdot}16 \times 10^{-12}$ gm./gm. which is in close agreement with the value obtained by J. Joly in 1911 for the radium content of the basalts of the Deccan.

Electricity and Magnetism

13. Magnetic susceptibility of some acetates in solution.

K. N. Mathur *and* S. N. Singh, Lucknow.

In the present investigation the magnetic susceptibility of solutions of acetates in water has been determined. The susceptibility-concentration

curves have been drawn. In case of sodium acetate solutions no deviations from additivity law has been observed, but the solutions of ammonium and lead acetates show large deviations. The susceptibility-concentration curves in the case of ammonium and lead acetate solutions show breaks at certain concentrations. A probable explanation of these breaks has been given.

14. A study of the variation of the specific resistance of some polycrystalline wires with plastic torsion.

N. RAM LAL, Hyderabad.

It was shown by Chalmers that the variation in the specific resistance of polycrystalline wires when they were stretched, was due to the rotation of their crystallites. These results were tested by X-ray methods by Gibbs and the author. In the present paper an attempt is made to study the change in the specific resistance due to torsion. For zinc (hexagonal) the resistance increases with torsion both at room temperature and at 98°C. For aluminium (cubic) there is no change in the resistance. These results have been satisfactorily explained. The work continues on other substances and X-ray tests will be applied.

15. Dip circle for measuring the earth's vertical field.

T. C. SEBASTIAN, Trivandrum.

A Dover dip circle has been adapted as a vertical intensity magnetometer by the substitution of the dip needle with a specially constructed variometer needle of the Schmidt pattern. Calibration of the instrument using an auxiliary magnet is also described. The arrangement is particularly suited for magnetic surveys, permitting the measurement of variations in dip and vertical intensity of the earth's magnetic field. The instrument is now being used for the magnetic survey of certain iron ore bearing regions in North Travancore.

Spectroscopy

16. On the band spectrum of phosphorus.

K. N. RAO, Kodaikanal.

The phosphorus bands were excited by passing an uncondensed discharge through phosphorus vapour and three aspects of the band spectrum of phosphorus were studied. Firstly, a fine structure analysis of the bands (9,21), (5,21), (5,18) and (4,18) was made and the rotational constants for the levels $v' = 4$ and 5 and $v'' = 18$ and 21 were newly obtained. From these the following values of B_e and α were obtained for the two vibrational states:

$$B_e' = 0{\cdot}2420;\ \alpha' = 0{\cdot}0017;\ B_e'' = 3187;\ \alpha'' = 0{\cdot}0021.$$

It has also been found that the perturbations pointed out by Herzberg associated with the level $v' = 5$ are only vibrational.

Elaborate quantitative determinations of the intensities of the lines in the (9,21), (5,18), (5,21) and (6,22) bands were made. The average value of the alternating intensity ratio was obtained as 3·0 giving a value of $\frac{1}{2}$ for the nuclear spin of the P_2 molecule.

Lastly, a search was made for the possible presence of the molecule of phosphorus in the solar atmosphere by studying the correlations between the laboratory wavelengths of the (8,27) and the (9,28) band lines in the near ultra-violet and those of the Fraünhofer lines recorded in the Rowland tables. It was concluded that the molecule of phosphorus exists in the solar atmosphere.

17. Effect of iodic acid on the principal water band of the Raman spectrum.

J. R. SARAF, Lucknow.

As a complementary study of the structure of the iodic acid molecules in solution, the present investigation reports the frequencies and intensities of the three components of the water band scattered in aq. solutions of iodic acid of concentrations ranging from 0·03*N* to 4·5*N*. The three frequencies $\Delta\nu$ 3213 (36·9),* 3424 (40·3) and 3613 (22·8) observed in 0·03*N* solution, shift to 3353 (31·3), 3519 (37·6) and 3620 (31·1) respectively when 4·5*N* solution is used, indicating a relative increase in the intensity of $\Delta\nu$ 3613 which is attributed to free H_2O molecules. The solute has been shown to cause a loosening and finally breaking up of hydrogen bonds uniting different H_2O molecules and as a result the number of free H_2O molecules increases at the expense of the bonded ones to which $\Delta\nu$ 3213 and 3424 are attributed.

Of all the acids studied so far, iodic acid is found to show the largest shift in frequency of the water band—a fact which may be due to the associated condition of the acid.

18. Complete Raman spectrum of the thiocynate ion.

J. R. SARAF, Lucknow.

The Raman spectra of KCNS and NH_4CNS solutions (aq.) show two Raman lines at $\Delta\nu$ 2667 and 767 in conformity with the observations of previous workers. The polarization measurements show that both the lines are polarized.

The fact that $\Delta\nu$ 2067 is polarized shows that the SCN^- ion possesses a bent unsymmetrical structure rather than a linear one. Such a conclusion has also been drawn by Bussem, Gunther and Tubin (*Z. physik. Chem.*, **24B**, 1, 1934) from an X-ray study of thiocynates.

The effect of KCNS (80% aq.) on the principal water band has also been studied. It is found that the shortest component of the water band becomes very weak, while the central maximum is split up into three components.

19. Flame bands and Hutchinson's theory of intensities.

N. R. TAWDE *and* J. M. PATEL, Bombay.

Swan bands in oxy-coal gas flames and air-coal gas flames have been examined. The flame was obtained as a jet from blow-pipe type of burner specially prepared for the purpose. Keeping the gas pressure constant, the pressure of oxygen or air was varied to give a certain ratio of pressures for coal gas to oxygen or coal gas to air. Two such ratios were selected for observation in each case, viz. 1·25 and 2·0. Intensities of bands under these conditions were measured by the rigorous methods of photographic photometry employing technique developed by the author and his collaborators. The results have been compared with the theoretical values computed from Hutchinson's intensity integral. The comparative rôles played by oxygen and air during the energy processes in their combustion with coal gas have been examined. The following conclusions have been drawn:—

(1) The experimental results depart considerably from the theoretical values except for the bands of lower quantum number, but comparatively, oxy-flames examined behave in closer approximation to theory than the corresponding air-flames.

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* Expressed as percentage intensity.

(2) With the given pressure of coalgas in the burner, the air pressure has to be increased to about 1·5 times the original value to correspond to radiative characteristics of the oxy-flame at the lower oxygen pressure.

(3) Theoretical results with quantum numbers of bands interchanges, are in closer approximations with experiment than with normal quantum numbers.

20. Direct method of measuring relative intensity distributions in line and band spectra.

N. R. TAWDE, Bombay.

Direct measurements of spectral intensity distributions have been made by an apparatus set up with the final aim of verifying similar measurements made by photographic photometry which has so far remained the only convenient and accurate method in the field. The arrangement consists of a rectifier type photo-cell as receiver connected directly to a galvanometer. The deflections of the latter have been amplified by an improved Barnes-Matossi type relay. The details of the apparatus and the experimental technique have been described and the precision of measurements estimated and fully examined for various factors.

The apparatus as evolved has been used to compute temperatures or relative intensities, as the case may be, by measuring the distribution of flux in the following:—

(i) Spectra of sources emitting continuous radiations: (*a*) Point-o-lite lamp operated under two different voltages, (*b*) the special G.E.C. lamp.

(ii) Line spectra of mercury arc excited at seven different current values.

(iii) Copper arc lines.

The results have been discussed and conclusions regarding the limitations of the method have been given.

21. A new interpretation of subsidiary bands in crystal luminescence.

C. S. VENKATESWARAN, Trivandrum.

The luminescence spectra of crystals, e.g. diamond, ruby, uranyl salts, etc., in general, consist of a complex system of bands. These are classified as (1) primary bands characteristic of electronic transitions in the solid as a whole or in the atoms constituting the solid, and (2) subsidiary bands characteristic of the crystal lattice. Recent investigations of Nayar (1939–42), Anna Mani (1942) and others have shown that the latter group of lines (or bands) owe their origin to the vibrations of the lattice. It is assumed that the lattice vibrations in the crystal result in the splitting of primary electronic transition levels and in the production of subsidiary levels in the crystal, enabling new transitions to take place.

The following alternative mechanism regarding the origin of these subsidiary bands may be suggested. It is a well-known fact that the intensity of Raman scattering in crystals is of the same order as that of Rayleigh radiation. In the ordinary solids which are micro-crystalline, the primary fluorescence light, which is emitted as a result of a photon encounter with the electrons in the crystal and its associated transitions, is scattered subsequently by the crystal lattice. The two processes are separate events, but occur successively. The scattering is as pure as in a single crystal and the stray reflections which enhance the intensity of the unmodified line in the Raman effect in crystals is almost completely absent.

The above interpretation of the subsidiary bands does not involve the splitting of the primary electronic levels by the lattice vibrations. The selection rules for these bands are the same as for the corresponding Raman line. They can be easily identified by their similarity to the primary fluorescence band in breadth and intensity distribution and by their Stokes' and anti-Stokes' relationships. A classification of the subsidiary bands to Raman and non-Raman bands has been carried out in a few typical cases.

22. The rotational frequencies of some simple molecules from their specific heat data.

C. S. VENKATESWARAN, Trivandrum.

A brief review of the specific heat theories of Debye, and Born and Kárman and of Raman is given. A method of deducing the rotational frequency of molecules from specific heat data is indicated and the corresponding frequency for a number of simple molecules is evaluated. These data are discussed in relation to the Raman and infra-red spectra and the Lindemann frequency obtained from the melting point of the compound.

Light

23. Experiments in scattered light. Angles of first minimum.

R. V. TAMHANKAR *and* G. R. PARANJPE, Bombay.

Starting with Mie's formula, the distribution of intensity of light scattered in the region of the transmitted direction has been studied theoretically for four drop-sizes of water vapour, viz. $\alpha = 15$, 20, 25 and 30, where α represents the ratio of the circumference of the drop to the wavelength of the light used. The range verified in the present investigations was 150–180. The calculations reveal that a sharp minimum of intensity exists in the range considered and that it has to be ascertained very carefully. This minimum, which is here termed as 'the angle of the first minimum on Mie's theory' may be correlated with the first order corona ring for the drop-sizes considered.

The theoretical results have been verified experimentally for the first time. The scattered intensity has been measured by the use of a photoelectric cell coupled with a suitable amplification arrangement. The results have been compared with Mie's theory and also with the first order corona ring. A fair agreement is found to exist in the cases considered.

24. On parabolizing a 24″ reflector.

S. HARIHARAN, Trivandrum.

In connection with the grinding, polishing and figuring of a 24″ glass paraboloid for a reflecting telescope—the largest of its kind in India—the author has worked out the technique of parabolizing polished concave surfaces.

The equation for a paraboloid is $y^2 = 2Rx$, where the focal length of the mirror is $R/2$, y is the perpendicular distance of any point on the mirror from the axis, x, the depth of the mirror below the chord joining the two points at a distance of y from the axis. To construct a perfect parabolic mirror, the radius of curvature R should vary from 0 to its maximum value at its edge in a regular fashion. The usual method of achieving this is to control the radius of curvature from zone to zone during the process of figuring. For this purpose the author has made use

of (1) the Foucault's knife-edge method, and (2) the Hartmann method, for determining the zonal values of R with suitable modifications. The paper describes the details of the processes adopted and the results obtained.

Electronics and Ionics

25. On the origin of the secondary extra reflections.

K. BANERJEE, Calcutta *and* C. K. BOSE, Dacca.

Lonsdale observed that in the more common variety of diamonds which is called class I, over and above the ordinary extra reflections, very sharp spots or streaks or both appear according to the orientation of the crystal. These are not appreciably temperature sensitive and are absent from the rare variety of diamonds called class II. Since the class I diamonds show greater extinction than the class II, she concluded that in the former internal strains exist while in the latter due to greater mosaicity the internal strains are relaxed. These sharp extra spots and streaks are, according to her, the result of the internal strain.

In the case of phloroglucine dihydrate it has been found that the secondary extra reflections can be photographed as a two-dimensional diffraction effect, by allowing the X-ray beam to be incident along the *c*-axis. The two-dimensional diffraction spots are found in the photographs taken to be extremely sharp having holes in the interior of the spots. This shows that only the outer portions of the crystal plates give rise to the secondary extra reflections while the inner portions do not show any such effect. According to Lonsdale's theory one should rather expect the opposite effect, as it is more probable that the outer portions of the crystal should show greater mosaicity and consequent release of strain than the interior.

26. Rectification in discharge tubes.

K. R. CHAUDHARI, Baroda.

Recently Chiplonkar has made some quantitative investigations (*Proc. Ind. Aca. Sc.*, **10**, 1939, and **13**, 1941) of the phenomenon of rectification in discharge tubes. His work is mainly confined to the study of the precise rôle of electrodes, their relative sizes and the inter-electrode distance in determining the rectification effect. This paper deals with a detailed study of rectification phenomena in air. The effect in hydrogen and CO has also been partly studied.

It appears from the experimental data that the maximum value of the rectification ratio ρ decreases with increasing density. The relation between ρ and pressure has been quantitatively studied. The pollution of electrodes by CO and other effects are also discussed.

27. Influence of temperature on the dissociation of strong electrolytes.

N. RAJESWARA RAO, Guntur.

In this paper, the effect of temperature on the dissociations of sulphuric acid, bisulphates and iodic acid is discussed. In all these cases, the substances are found to dissociate less at higher temperature. While for concentrated solutions of sulphuric acid, the rate of decrease of dissociation with temperature is less in dilute solutions, in the other cases it was found to be larger leading to the conclusion that at higher temperatures, the rate of dissociation with dilution is less for the latter type of substances and more for the former.

Borderline Fields

28. Relative abundance of isotopes and thermodynamic equilibrium.

D. S. KOTHARI *and* R. N. RAI, Delhi.

The relative abundances of isotopes are used to determine the temperature and neutron concentration for an assembly (in thermodynamic equilibrium) in which the isotopes in their present proportions would constitute an equilibrium mixture. For an element which possesses three or more isotopes, the above-mentioned properties of the assembly can be determined from the relative abundances of its own isotopes. But in the case of elements possessing only two isotopes, we have to make use of two elements. The temperature of the assembly in both cases can be readily estimated from the figure given in the paper, and the neutron concentration is also easily obtained. In the case of some elements the temperature comes out to be negative. The rôle of non-equilibrium reactions in determining relative abundances of elements is mentioned.

29. Rainfall zones of the Patiala State.

L. D. MAHAJAN, Patiala.

The rainfall in the Patiala State has been studied. The area of the Patiala State, which forms the south-eastern part of the Punjab, has been divided into zones, having different ranges of rainfall. These zones run roughly parallel to one another and to the Himalayan ranges from S.E. to N.W. direction. The rainfall decreases from the N.E. to S.W. direction.

The views of the early workers on the rainfall zones are discussed in the paper.

30. 'Coercive time' and 'residual' humidity of hygrometers.

L. D. MAHAJAN, Patiala.

The relative humidity as indicated by a hygrometer increases rapidly in the beginning, but this rate of increase decreases rapidly with time. After the hygrometer has attained a constant value, and the R.H. of the surrounding medium is reduced to the initial value, the reading as indicated by it decreases rapidly in the beginning, and the rate of decrease falls rapidly with time. Thus the instrument when the humidity is increasing gives a curve of a different shape from that when humidity decreases with time. On the return path, it takes a longer period to represent the initial reading. The additional time taken is the 'coercive time'. Moreover, after the same interval, it represents higher value than before. The difference is called here the residual humidity.

In this paper, the methods used for the above purpose, the values of coercive time and residual humidity, and the discussions of the results are given in detail.

31. The lunar atmospheric tide at Bangalore, 1895–1904.

C. SESHACHAR *and* V. R. TIRUVENKATACHAR, Bangalore.

The lunar atmospheric tide at Bangalore has been determined, using the data for 1895–1904. The result is that the semi-diurnal component of the annual mean tide at Bangalore may be represented by 46 sin $(2t+84°)$. The seasonal variation of the tide is similar to that at most other stations in that the amplitude and phase are minimum in winter. The dependence on lunar distance is also well shown, the amplitude at Apogee being much less than that at Perigee. A comparison of the results for Bangalore and other stations at different altitudes suggests that the amplitude diminishes

with increasing altitude—a conclusion opposed to the one arrived at by Pramanik and others.

32. Dual and self-dual tensors in wave-tensor calculus.

BRIJ NATH, Arrah.

In ordinary tensor calculus, corresponding to an antisymmetric tensor there are two dual and two self-dual tensors. But in the wave-tensor calculus, there are six dual and six self-dual tensors corresponding to an antisymmetric *E*-numbers. These tensors cannot be obtained from one another by relativistic transformations.

Radio

33. Effect of water vapour in the atmosphere on the propagation of ultra-short radio-waves.

S. S. BANERJEE, Poona.

In view of the wide applications of ultra-short radio-waves, specially in connection with television, aviation and radio sounding balloons, an attempt has been made to calculate the amount of bending of these waves during their passage through the normal lower atmosphere over India when laden with moisture up to different levels. It has been shown that water vapour may be capable of bending these waves along the curvature of the earth or even more.

Two possible cases have been considered for calculation. Firstly, when the air is saturated up to a certain level and contains water in the vapour form only. Secondly, when such a layer is pushed up by one km. due to convection or any other meteorological phenomenon, assuming that there is no loss of water during the process and the excess of water condensed due to lowering of temperature is suspended in droplet form without formation of ice.

It has been shown that in the normal atmosphere over Poona in the month of May, saturation up to a level of 3 to 5 km. will be capable of bending ultra-short waves along the curvature of the earth; and when the lower layers of the atmosphere are raised, pronounced bending may occur at lower levels which may cause fading of signals and also give rise to measurable errors in actual bearings while locating an aircraft or a radio sounding balloon.

34. Critical survey of recent theoretical work on ionosphere.

A. PANDE, Delhi.

In recent years a number of theoretical papers have been published on Ionosphere. After a study of those papers one finds a great deal of inconsistencies in the various results and assumptions. In this paper the whole theoretical work on ionosphere has been divided into the following six sections:—

(1) The determination of ionization densities of *E* and *F* layers.
(2) The propagation of electromagnetic waves through Ionosphere.
(3) The dissociation, recombination and attachment processes in the Ionosphere.
(4) The determination of electron collisional frequencies in the Ionosphere.
(5) The temperature and compositions of the Upper Atmosphere.
(6) The practical applications of the theoretical work.

The paper gives a critical discussion of previous work on this subject and the underlying assumptions have been thoroughly examined. Finally,

the necessity for calculating the temperature of the Upper Atmosphere from independent data has been stressed.

35. Investigation on the dielectric properties of different Indian soils at medium radio frequency.

J. N. Ray *and* S. R. Khastgir, Dacca.

The effective dielectric constant and electrical conductivity of different soils from various parts of India were determined on medium radio frequencies under various controlled conditions. From these data the *true* dielectric constants were evaluated.

The following studies were made:—

(1) The effect of packing.
(2) Variation of the soil constants with moisture content.
(3) Variation of the soil constants with frequency.
(4) The effect of temperature.
(5) Comparison of electrical constants for soils from different places.

A general interpretation of all the experimental results is given. The variation of the soil constants with frequency has also been examined in the light of Debye's theory.

SECTION OF CHEMISTRY

President :—R. C. Ray, D.Sc., F.I.C.

Inorganic Chemistry

1. Tervalent silver compounds.

Priyadaranjan Rây *and* Kshitis Ranjan Chackrabarty, Calcutta.

A number of four co-ordinated silver ethylenedibiguanide salts, in which the central silver atom shows rather strikingly a primary valency of three, has been prepared. Their composition is given by:

$$[Ag^{III}En(BigH^-)_2]X_3,$$

where $X = SO_4$, NO_3, ClO_4, or OH, and $En(BigH)_2$ = one molecule of ethylenedibiguanide = $C_6N_{10}H_{16}$, which behaves as a quadridentate molecule. The salts form beautiful, needle-shaped, prismatic crystals of deep red colour, the base being violet-red, and are quite stable at ordinary temperature (20°–25°). The nitrate can be recrystallized from dilute nitric acid.

The salts liberate *two* equivalents of iodine for every silver atom from acidified KI-solution. The molecular conductivity of the nitrate corresponds to that for a tervalent complex ion. The salts, unlike those of bivalent silver, are *diamagnetic*.

A tervalent silver atom should possess the same electronic structure as bivalent nickel and hence its complexes would be diamagnetic like the planar nickel complexes, if the co-ordination bonds be of the hybrid d-s-p^2 type. Tervalent silver, therefore, resembles tervalent gold of the same periodic group forming four co-ordinated planar complex of the penetration class.

2. Hydrides of cobalt.

R. B. N. Sahai *and* R. C. Ray, Patna.

In a previous paper (*J.I.C.S.*, 1943, **20**, 213) the preparation and properties of hydrides of nickel have been described. Hydrides of cobalt have been prepared in the same apparatus using the same method as described in the previous paper. Two hydrides of the compositions CoH_2 and CoH have been obtained. Decomposition pressures have been measured at different temperatures and the pressure-temperature relationship determined. Heats of formation have been calculated from the decomposition-pressure-temperature curve. They come out as 29,200 cals. and 13,500 cals. for CoH_2 and CoH respectively as against 35,200 cals. and 17,100 cals. for the corresponding nickel compounds. It has been found that the cobalt hydrides are actually less stable than their nickel analogues.

3. Pyridine complexes of metallic perchlorates. Part II.

P. C. Sinha *and* R. C. Ray, Patna.

Pyridine compounds of certain metallic perchlorates were described in a previous paper (*J.I.C.S.*, 1943, **20**, 32). The dissociation pressures of copper pyridine perchlorate have been measured at different

temperatures between 35° and 100°. From the data the heats of formation have been calculated by the formula, $Q = RT^2 \frac{dlnp}{dt}$. The isothermal curve for the system, $Cu(ClO_4)_2$—pyridine, has been determined at 40°, and this shows the existence of two compounds of the formulæ, $Cu(ClO_4)_2$—6 pyr. and $Cu(ClO_4)_2$—4 pyr. The affinities which hold the pyridine in the copper compounds seem to remain constant throughout the range of temperatures investigated.

4. Co-ordination compounds of mercury with benzidine and *o*-tolidine.

KANAI LAL MANDAL, Calcutta.

The organic bases that have been used in preparing complex mercuric salts are benzidine and *o*-tolidine. It has been observed that the mercuric salts in general form complex salts with benzidine having the formula $[HgBz]X_2$ (Bz = benzidine, X = univalent acid radical). The co-ordination valency of mercury in these compounds is 2. The property, unique in this class of compounds, is that they form addition compounds with pyridine, piperidine and aniline, in which mercury shows unusual co-ordination valencies, namely, 3 and 4.

The 3-co-ordination compounds are formed by the addition of a molecule of pyridine, piperidine and aniline to a molecule of the benzidine mercuric salt. The addition compounds with pyridine and piperidine are very stable, but those with aniline are hydrolyzed by water and lose the addendum in air. It appears possible to detect mercury in aqueous solution by a reagent containing equimolecular proportions of benzidine and pyridine. The bright yellow precipitate which is formed quantitatively on warming is characteristic of mercury.

In absence of water, pyridine and piperidine form 4-co-ordination compounds with not only some of the complex benzidine salts of the oxyacids of mercury but also the complex halides.

o-Tolidine behaves generally like benzidine towards mercuric salts and forms 2-, 3-, and 4-co-ordination compounds of mercury.

5. Co-ordination compounds of mercuric salts with phenylene-, toluylene-, and naphthylene diamines.

KANAI LAL MANDAL, Calcutta.

Complex mercuric salts with three isomeric (*o*-, *m*-, *p*-) phenylene diamines, one toluylene diamine (2 : 4), two isomeric naphthylene diamines (1 : 8 and 1 : 2) have been prepared and studied. Whilst other bivalent metals show varying co-ordination valencies, mercury exhibits in these compounds the co-ordination number 2 only, which is not increased through formation of additive compounds. Salts of the diamines, too, combine in equimolecular proportions with the mercury salts.

ortho-Phenylene diamine mercuric salts are distinguished from the other salts of this group in showing the rare phenomenon of existing in more than one form. The two forms differ in melting point. It has not been possible to bring out clearly how the two forms are related.

Mercury compounds with chrysoidine and 2 : 3-diaminophenazine have also been prepared.

6. Co-ordination of mercury salts with ethylene and propylene diamines.

KANAI LAL MANDAL, Calcutta.

No systematic study has been made of the compounds of mercury with ethylene diamine and its homologues. Mercury is known to form

with ethylene diamine both mono- and di-compounds. The di-compounds have special interest because in these compounds mercury has the rare co-ordination number 4.

A number of unusually stable bismercuric salts have been prepared. In these compounds, a molecule of the mercuric salts combines with either two molecules of ethylene diamine or two molecules of propylene diamine. Though the compounds prepared do not include the complex halides, the chloroplatinites and chloroplatinates have been obtained. This type of 4-co-ordinated mercury compounds is not known to have been prepared before. It has been possible to estimate mercury in a simple way as *bis* chloroplatinites and chloroplatinates.

A number of mono-compounds have also been prepared.

7. Co-ordination compounds of mercury with salts of ethylene and propylene diamines.

KANAI LAL MANDAL, Calcutta.

Few mercury complexes with ethylene diamine and propylene diamine, or with their salts have been prepared. In the compounds described, a molecule of the mercury salts has combined with either one or two molecules of the salts of a diamine. A number of both types of compounds have been prepared with salts of ethylene diamine as well as propylene diamine.

Mercury compounds with two molecules of the salts of the diamines are formed as easily as those with one molecule of the diammonium salt. The compounds may have mixed anions or one kind of anion. The compounds are no doubt unusual types of salts. If mercuric di-ethylene-diammonium salts be expressed as complex salts of the general structure $[Hg(C_2H_{10}N_2)_2]X_2Y_4$, mercury in these compounds assumes the rare co-ordination valency 4. The same is also the case with mercuric di-propylene-diammonium salts.

8. A note on the manganese content of the seeds of *Mucuna Pruriens*.

P. V. NAIR *and* K. S. MADHAVAN PILLAI, Trivandrum.

The ash of the seeds of *Mucuna Prurita*, Hook, Syn. *Mucuna Pruriens*, Bak. in Hook (N.O.: Papilionaceae), has been found to contain 34·2% of phosphorus (as P_2O_5), 16% sulphur (as SO_3) and 0·56% manganese. The manganese content was estimated by the colorimetric method of Retortillo and Callego; and also checked volumetrically by titrating with 1% solution of H_2O_2. The same solution prepared for the colorimetric estimation was used for the volumetric estimation also. The aphrodisiac and general tonic action of the seeds claimed by the Ayurvedic and Unani pharmacists may be traced to the presence of such ingredients as manganese, phosphorus (as lecithin) and sulphur (as thiol compounds).

9. The action of charcoal on sodium nitrite.

T. M. OZA, Dharwar.

In order to confirm the production of nitrous oxide detected in the slow reaction between potassium nitrite and charcoal (*J.I.C.S.*, 1943, **20**, 267) and elucidate its origin, these experiments have been performed. The reaction starts at 300° and becomes violent at 360–65° and is, therefore, accessible for study under different conditions.

Experiments with weighed quantities of the reactants, *in vacuo*, reveal the presence of large (about 50%) amounts of nitrous oxide mixed with nitrogen, carbon dioxide, nitric oxide and carbon monoxide in the gaseous products and sodium nitrite, carbonate and, perhaps, sodium but no nitrate in the residue. No hyponitrite could, so far be detected in

the residue. The composition of the gas remains unaltered whether it is continuously pumped off or allowed to accumulate in the system during the reaction at a constant temperature. The increase of the mass of the reactants or the proportion of charcoal or the temperature (within the range of regulated reaction) of the reaction tends to produce more nitrogen. The proportion of nitrous oxide in the violent stage is comparatively very small.

It is difficult to ascribe the formation of nitrous oxide to the production and decomposition of sodium hyponitrite formed as an unstable intermediate product in the reaction as nitrous oxide is not found amongst the products of decomposition of sodium hyponitrite (Divers, *J.C.S.*, 1899, **47**, 97; Partington and Shah, *J.C.S.*, 1931, 2071).

Experiments to study (i) the reactions of hyponitrites in solution, (ii) the thermal decomposition of sodium hyponitrite, are in progress and a study of the action of charcoal on oxides of nitrogen, under the conditions of these experiments, may be undertaken if found necessary.

10. The thermal decomposition of nitrites.

T. M. Oza *and* B. R. Walavalkar, Dharwar.

As potassium nitrite melts with decomposition (Oza and Walavalkar, *J.I.C.S.*, 1943, **20**, 317) and appears to decompose even before its melting point (Oza and Shah, *J. Univ. Bom.*, 1942, XI, 56; *J.I.C.S.*, 1943, **20**, 261), the initial products of the decomposition have been swept out by streaming a current of carbon dioxide on the substance, *in vacuo*, at its melting point. Experiments have also been performed with (1) sodium nitrite, and (2) magnesium nitrite, at or near their melting points. The gases are collected over Sprengel pump after allowing them to bubble in strong KOH solution, through an internal seal.

The experiments reveal the production of fairly good amounts of nitrite (and not a trace of nitrate) in the alkali absorbent. The gas collected is pure nitrogen in the case of potassium and magnesium nitrites and nitrogen mixed with nitric oxide in the case of sodium nitrite. An experiment performed to generate carbon dioxide within the decomposing mass with sodium nitrite—heating an intimate mixture of sodium nitrite and magnesium carbonate—showed the production of pure nitric oxide in the gas. In all cases the solid residue contains nitrate in amounts depending upon the amount and nature of the gas collected. The results of experiments with carbon dioxide as sweeping agent are confirmed by using nitrogen instead.

The results confirm the reversible stage, $2KNO_2 \rightleftarrows K_2O + NO_2$, in the decomposition of nitrites and throw considerable light on the other stages (Oza and Shah, *J. Univ. Bom.*, 1942, XI, 70) in the decomposition of nitrites. Experiments on the effect of nitric oxide on the nitrites, at their melting points, under different pressures are in progress. These are expected to clarify the other stages completely.

Physical Chemistry

11. Gray and Cruickshank's method and the diamagnetic susceptibilities of dicyandiamide, acetamide and cyanuric acid.

Sushil Kumar Siddhanta *and* Priyadaranjan Rây, Calcutta.

Magnetic susceptibilities of dicyandiamide, acetamide and cyanuric acid have been measured on very carefully purified specimens. The values found have been compared with those calculated by Gray and Cruickshank's method, using the resonating structures established by

X-ray analysis of their crystals. A survey of the results indicates that though the values given by Gray and Cruickshank's method of calculation prove to be a decided improvement upon those derived from Pascal's procedure, still the agreement between the experimental and calculated values is not sufficiently close in all cases. In the case of cyanuric acid, there is a large difference between the two values for every possible single or resonating structure of the molecule. Unless the method is further refined, it cannot be viewed upon as a reliable means for exploring the structure of molecules.

12. Flow of air through consolidated sands partly saturated with water/kerosene.

N. C. SEN-GUPTA, Calcutta.

Variations in the permeability to air of cores partly saturated with liquid have been studied using some cores from Digboi wells and cores prepared from cement-sand mixtures. The experimental arrangement was a slight modification of that previously described by the author. When permeabilities are plotted against the corresponding percentage liquid saturations, two types of curves are obtained. In the first type, which is more common, liquid saturations up to 10% do not markedly alter the permeability but with further increase in the liquid saturation the permeability falls first slowly and then rapidly; beyond 50 to 60% saturation the rate of fall of permeability again diminishes until zero air-permeability at complete liquid saturation of the core is asymptotically approached. In the second type of curve the permeability diminishes rapidly with increase in liquid saturation until about 20 to 30% saturation is reached. Beyond this the permeability falls slowly to zero as the liquid saturation approaches 100%. The use of water or kerosene produces the same type of result, showing that surface tension has practically no effect on the nature of the curves.

13. Velocity of hydrolysis of anilides.

B. W. KELKAR, K. K. DOLE *and* D. D. KARVE, Poona.

The hydrolysis of anilides of various aliphatic acids has been studied in water and also in water containing varying proportions of alcohol, using sulphuric acid as a catalyst. In alcoholic solution the values of *K* are seen to fall owing to the interaction between the liberated acid and the solvent alcohol. After the establishment of the equilibrium in this reaction the values of *K* remain constant. The order in which the velocities of hydrolysis decrease is—

Formanilide → form-*p*-toluidide → form-*o*-toluidide → *p*-nitro-acetanilide → *o*-nitro-acetanilide → acet-β-naphthalide → acet-α-naphthalide → propionanilide → acetanilide → acet-*p*-toluidide → acet-*m*-toluidide → *p*-brom-acetanilide → acet-*o*-toluidide.

14. Study of some consecutive reactions: Hydrolysis of nitriles.

G. G. MAJUMDAR, K. K. DOLE *and* D. D. KARVE, Poona.

The hydrolysis of nitriles is studied in the presence of 22·00*N* sulphuric acid as catalyzer. The reaction is an illustration of two pseudo-uni-molecular and non-reversible consecutive reactions. Thus,

$$R.CN \xrightarrow{H_2O} R.CONH_2 \xrightarrow{H_2O} R.COONH_4.$$

As in all consecutive reactions, the hydrolysis of nitriles also exhibits a period of induction. This period of induction is followed by a period of acceleration, at the end of which the values of *K* become constant. The end of the first stage of the reaction ($R.CN \rightarrow R.CONH_2$) is simultaneous

with the end of the period of acceleration. The reaction has been studied in formic acid and propionic acid as solvents, as well as in glacial acetic acid.

Some aromatic nitriles also have been studied, with 22·00N-sulphuric acid at different temperatures. Their study shows that they behave just like aliphatic nitriles and the values of the velocity constants depend upon the nature of the substituents.

The temperature coefficients of all reactions show an increase in the coefficient with the rise in the temperature, indicating that the activation energies are different for the two stages of the reaction.

The hydrolysis of nitriles with hydrochloric acid as catalyzer is more rapid than that with sulphuric acid. The effect of the change of concentration of the catalyzing acid on the two stages of the reaction is being investigated at present.

15. Kinetics of the reduction of potassium chlorate by an acidified solution of sulphur dioxide.

G. B. Kolhatkar *and* U. A. Sant, Poona.

$N/50$ solution of potassium chlorate is reduced at 26° by $N/50$ acidified solution of sulphur dioxide and the concentration of sulphur dioxide in the reaction mixture is estimated from time to time by $N/50$ solution of potassium permanganate.

The results obtained give a velocity constant when substituted in the equation of a bimolecular reaction.

16. Kinetics of reactions in heterogeneous liquid-liquid systems.

P. S. Javadekar, K. K. Dole *and* D. D. Karve, Poona.

The reactions between β-naphthoic acid in chlorobenzene and aqueous sodium hydroxide has been studied. Temperature coefficients indicate the predominance of the diffusion factor in this reaction and consequently a change in speed of stirring has a marked effect on the velocity of this reaction.

Interfacial tensions between the phases have been studied. Benzoic acid diminishes the interfacial tension between chlorobenzene and water, while diphenyl increases it noticeably. Hydrochloric acid lowers the tension, but the lowering is not so remarkable as in above cases. Potassium sulphate also does not show any remarkable influence. At higher temperature the interfacial tension is diminished slightly.

From the interfacial tensions studied in cases of benzoic acid and diphenyl, it can be said that the substance which decreases the interfacial tension, increases the velocity of reaction and *vice versa*.

17. Base-exchange equilibria in permutites. I. Effect of anions.

M. R. Nayar *and* O. Talibuddin, Lucknow.

The specific effect of different anions on the release of calcium from Ca-permutite by sodium salts of mono-, di-, tri-, and tetra-basic acids has been studied.

In all cases the curves obtained showed that the release of Ca ion followed a modification of the Freundlich adsorption isotherm: $y = aC^{1/n}$ where y is the Ca released in m.e., C the *initial* concentration of the added electrolyte, and a and n constants.

To release the same amount of Ca different concentrations of electrolytes were required. But the sodium ion activity calculated according to Debye-Hückel formula shows a remarkable constancy (about 0·7) for a

large number of electrolytes which may be termed 'neutral'. Acid salts, e.g. $Na_2Cr_2O_7$, give a higher value, while salts of weak acids, e.g. Na_2CrO_4, $Na_2B_4O_7$, yield a much lower figure, indicating the influence of pH.

An attempt has been made to find a relation between the constants a and n.

18. Effect of common ion on the dissociation of stray electrolytes.

N. Rajeswara Rao, Guntur.

In the present part, investigations on the effect of common ion on the dissociation of iodic and trichlor-acetic acids is dealt with. The dissociation of iodic acid is studied as influenced (1) by hydrogen ions supplied by HNO_3, and (2) by IO_3 ions supplied by $LiIO_3$. In the former case, the dissociation is suppressed, while in the latter, it is enhanced, in agreement with the results with substances reported in the previous parts. In trichloro-acetic acid, the influence of hydrogen ion by the addition of HCl alone is studied, and it is found that the dissociation is suppressed as in all the previous cases.

19. Donnan membrane potential.

S. G. Chaudhury, Calcutta.

According to Donnan at the same pH of the protein solution, the ratio of the potential difference for the di-basic acid to that for a mono-basic acid should be as 2 to 3 or ·66 nearly.

According to the author at the same pH value of the solution the ratio of the potential difference (E_m') for the di-basic acid to that (E_m) for a mono-basic acid should be

$$\frac{E_m'}{E_m} = \frac{\frac{RT}{N^*F}\cosh^{-1}\frac{3y+Z}{3x}}{\frac{RT}{N^*F}\cosh^{-1}\frac{2y+Z}{2x}} = \cdot 66 \text{ nearly,}$$

where $N^* = \frac{N_1+N_2}{2}$; $N_1 =$ the valency of the cation, $N_2 =$ the valency of the anion and Z is small.

20. A note on Debye-Hückel equation and the relation between dielectric constant and temperature.

Balbhadra Prasad, Cuttack.

It is shown that if Debye-Hückel equation were correct, then dielectric constant of a liquid would be inversely proportional to temperature. This relation between dielectric constant and temperature is nearly constant in case of water. In case of other solvents, the relationship is not even approximately correct. The work on the polar molecules also seems to be against such a simple relation. It is quite possible that the difference between the calculated and observed activity coefficient as well as the relationship between dielectric constant and temperature is due to the same mistakes in the derivation of the equation.

21. Rheochor.

L. N. Srivastava, Lucknow.

Recently Dr. J. Newton Friend enunciated a new property, the 'Rheochor', by replacing $\sigma^{\frac{1}{4}}$ by $\eta^{\frac{1}{8}}$ in Sugden's expression for parachor

(*Nature*, 1942, **150**, 432). The equation, thus obtained, is $M\frac{\eta^{\frac{1}{8}}}{D} = R$, where M is the molecular weight, D the density, η the viscosity, and R the 'Rheochor'.

R has been calculated from available data for a number of liquids like hydrocarbons, alcohols, esters, acids and water.

In the case of non-associated liquids, R is a constant (independent of temperature) within about 0·5%. In the case of associated liquids, e.g. water and alcohols, R continuously decreases with temperature. In the case of isomeric esters differences in R have been noted. Within limits the rheochor of solutions follows the mixture law.

In general, rheochor has the same applicability as parachor, with the added possibility of revealing finer differences in structure.

22. The cryoscopic constant (K) for bromo-camphor.

A. VENKITACHALAM, A. N. POTI *and* R. R. IYER, Trivandrum.

In this laboratory 3-bromo-camphor has been found to be an excellent solvent for the determination of M.W. in solution of organic substances by the cryoscopic method. It is easily purified, has a conveniently low m.p., a high depression constant and is capable of dissolving a variety of substances. The present paper deals with the determination of its constant (K) with substances of known molecular weight and comparing the value so obtained with that calculated from the latent heat using the formula $K = \frac{0{\cdot}002T^2}{L}$ (where T = m.p. on the absolute scale, L = latent heat of fusion for 1 gram).

The experimental and calculated values are in good agreement.

23. A thermodynamical derivation of the relationship $\lambda(T_s-T) = 2M\sigma/\rho r$ = a constant.

RAMA GOPAL, Lucknow.

An attempt has been made to prove the above relationship thermodynamically by considering the process of solution and crystallization as a reversible cycle. This relationship has been experimentally proved in the cases of some salts of sodium and potassium (*J.I.C.S.*, 1943, **20**, 187).

24. Supersaturation limits of solutions. Part II.

A. C. CHATTERJI *and* RAMA GOPAL, Lucknow.

In continuation of the previous work on the limits of supersaturation (*J.I.C.S.*, 1943, **20**, 187), a few more substances have been investigated and it has been shown that, in general, $\lambda(T_s-T)$ is approximately proportional to the product σVm, the terms used having their usual significance. As a result of this relationship $\lambda(T_s-T)$ is found to be almost a constant in cases where σVn values are approximately equal.

Based on above considerations, a method for calculating the radius of the stable crystal nucleus has been developed. The values of r for different T_s are given by the expression: $r = 0{\cdot}036T_s \times 10^{-7}$ cm.

On the assumption that the factor T_s/r is a constant in the cases of halides and nitrates of K, Rb, and Cs an estimate of the limits of supersaturation has been made by the equation $(T_s-T) = 13\frac{\sigma Vm}{\lambda}$ and it has been shown that T_s-T for K, Rb, and Cs salts of the same acid varies inversely as their respective molecular weights.

25. Supersaturation limits of solutions. Part III.

A. C. CHATTERJI *and* RAMA GOPAL, Lucknow.

The effect of continuous heating for various periods of time on the limits of supersaturation has been studied. It is found that in certain cases, e.g. KNO_3, $NaNO_3$ and $KClO_4$, etc., the effect is negative or negligible even when the tubes are heated up to 18 hours at 90°. But this effect is very much pronounced in the cases of $Ba(NO_3)_2$, NH_4Cl, and $(NH_4)_2SO_4$, etc. No explanation is given as to the cause of this difference in behaviour. Further work is proceeding on the subject.

26. Rôle of manganous ions in photo-chemical reactions.

T. N. SRIVASTAVA, Lucknow.

In this paper the effect of Mn^{++} ions has been studied on the following photo-chemical reactions: (*a*) sodium tartrate-iodine, (*b*) sodium citrate-iodine, (*c*) sodium malonate-iodine, (*d*) sodium lactate-iodine, (*e*) sodium formate-iodine, (*f*) ferrous sulphate-iodine, and (*g*) sodium nitrite-iodine.

It is observed that in the cases of first four reactions, addition of Mn^{++} ions increases the rate of photo-reaction; the increase being directly proportional to the quantity of Mn^{++} ions added and to the intensity of illumination. No appreciable effect of Mn^{++} ions is observed if the reactions are carried out in dark. The catalytic effect of Mn^{++} ions is also observed even when the reactions are carried out under nitrogen. The effect of Fe^{+++} ions, another photo-catalyst, has also been studied and observed to show similar effects as Mn^{++} ions.

Further work is necessary for suggesting a satisfactory explanation and is in progress.

27. Reduction of gold chloride by carboxylic acids.

T. N. SRIVASTAVA, Lucknow.

The reduction of gold chloride by the carboxylic acids, maleic and lactic acids, in presence of small quantities of $KMnO_4$ has been studied with the following results:—

Maleic acid.—Reduction is photo-chemical and somewhat accelerated by atmospheric oxygen. Increase in temperature and concentration of the acid increases the rate of reduction. In presence of small quantities of $KMnO_4$, the acid acquires strong reducing power, probably due to the formation of meso-tartaric acid, which is one of the oxidation products. Further work regarding the actual identification of the acid formed is in progress.

Lactic acid.—This reaction is also photo-chemical, but inhibited by atmospheric oxygen both in light and dark just like oxalic acid—gold chloride reaction. Effect of temperature and concentration of the acid is the same as above. However, when the reaction is carried out in presence of small quantities of $KMnO_4$, enhanced reducing power like other carboxylic acids is not observed.

Hence these reactions appear to support the view previously put forward that the production of some intermediate compound with strong reducing property is responsible for the enhanced activity of carboxylic acids (when treated with $KMnO_4$) towards gold chloride.

28. Reaction between sodium citrate and iodine.

T. N. SRIVASTAVA, Lucknow.

This reaction previously studied by Dhar and co-workers (*J.I.C.S.* 1925, **2**, 282; 1929, **6**, 455; *J. Phys. Chem.*, 1928, **32**, 1313; 1929, **33**'

851), who observed a measurable rate of reaction in dark and light, was repeated by using a glass-stoppered bottle, as it was suspected that the use of beakers as done by Dhar and Mukerji (*J.I.C.S.*, 1925, **2**, 278) might lead to erroneous conclusions due to loss of iodine. Contrary to the observations of Dhar and co-workers, it is found that the reaction does not proceed with any measurable velocity at ordinary temperatures either in dark or light. Effect of varying the temperature (20°–40°) and the concentration of reactants is negligible. An extremely slow reaction rate is also observed at 60°.

In order to explain the measurable rate of the reaction at ordinary temperatures, observed by Dhar and co-workers, the effect of various impurities like Fe^{++}, Fe^{+++}, and Mn^{++} ions have been tried but all of them produce no appreciable effect in the dark, while in visible light Fe^{+++} and Mn^{++} ions accelerate the reaction. The effect of Mn^{++} ions is very pronounced and only few mgs. produce tremendous increase in the reaction velocity, with the formation of a solid compound which appears to be identical with hexa-iodo-acetone. The analysis of the compound is in progress.

29. Reaction of SO_2 and N_2O in silent electric discharge.

G. S. Deshmukh *and* B. S. R. Sastry, Benares.

This reaction has been studied under electric discharge due to alternating potentials varied over a wide range at a frequency of 50 cycles per second of the A.C. supply. The proportion of the two components has been fixed and the gas pressure varied in the range 20–400 mm. Hg. Results are normal at low initial pressures when a progressive diminution of the pressure is produced reaching a constant stage. This diminution has been traced to the absorption of nitrogen by sulphur deposited on the inner walls of the reaction vessel due to the decomposition of SO_2. The variation in the ionization current has also shown a remarkably synchronous parallelism with the pressure-time curve. The presence of sulphur nitride produced under discharge in the above conditions has been established and this accounts for the pressure diminution. Presumably a portion of the sulphur nitride decomposes during the last stage of the reactions. It may also be assumed that the absorption of N_2 by sulphur reaches a saturation stage, and the observed pressure reversal may be due to the liberation of the absorbed gas and also due to the accumulation of N_2 and O_2 by the subsequent decomposition of N_2O. The analysis of the decomposition products supports this assumption and a theory has been proposed for the mechanism of the change under the discharge.

30. Interaction of SO_2 and H_2 under electric discharge.

G. S. Deshmukh *and* Banamali Lahiry, Benares.

Interaction of SO_2 and H_2 under electric discharge has been investigated. This work was undertaken with a view to extending the results obtained in the interaction of N_2O and H_2 (Joshi and Deshmukh, *Proc. Indian Sci. Cong.*, 1941, Part III, p. 54). The proportions of the two components have been varied over a wide range, and the reaction has been studied at definite applied potentials. Results of a series of experiments do not reveal the 'periodicity effect' observed during the interaction of N_2O and H_2. The threshold potential for the decomposition of the mixture of SO_2 and H_2 is defined much less sharply and the pressure invariably diminishes during the course of the reaction. The corresponding discharge current increases initially exhibiting a sort of 'zonal effect', but reaches the steady stage simultaneously along with the pressure. While H_2S, H_2O and sulphur are the sole products in the thermal reaction, the discharge reaction yields besides undecomposed

SO_2, H_2S, O_3, H_2O, free sulphur deposited on the walls of the reaction vessel, and presumably some H_2SO_3 and H_2SO_4, depending on the stage of the decomposition, produced at a given potential.

A theory has been proposed for the mechanism of the reactions.

31. The new light effect in hydrogen under electrical discharge.

S. S. Joshi *and* S. R. Agrawal, Benares.

It has been reported by Joshi and co-workers that hydrogen showed the least 'light effect', denoted by Δi the diminution of the discharge current in the gas on irradiation. This phenomenon has now been studied as a function of applied voltage, the gas pressure, frequency of the A.C. supply, intensity and frequency of irradiation and 'ageing'. It is observed that at moderately high pressure Δi tends to increase by increasing V the potential applied to the discharge tube; the increase of Δi with V then comes to a standstill and begins to diminish; at large secondary potential about 4000 volts (r.m.s.), Δi is practically nil. At lower pressures, the decrease of Δi with V is more gradual. The light effect is negligible at pressures below 3 cm. Hg.

The effect of 'ageing' the gas under the electrical discharge is to reduce the 'light effect'.

No appreciable change is produced in Δi by changing the current frequency from 50 cycles to 500 cycles per second.

The light effect diminishes on diminishing the intensity of irradiation. It is observed that Δi changes sensibly under violet>green>and>red light; this is in agreement with Joshi's suggestion that, in general terms, the present phenomenon is more a frequency or a quantum effect than a consequence of *selective* optical absorption.

32. On the use of a polaroid-pair as an intensity-variometer. Part I.

P. G. Deo, Benares.

During work on a new light effect in chlorine (Joshi and Deo, *Nature*, **1943**, **151**, 561) it was found that whilst the effect varied markedly with α the inter-polaroid angle, J the transmitted intensity as determined with a thermopile or a photo-cell changed but little. A general study of the intensity-variation with α appeared, therefore, to be desirable.

A consideration of the dichroism and birefringence of the microcrystals constituting the polaroid material set in a (partially birefringent) cellulose matrix, led Graban to deduce,

$$J = \frac{1}{2} I_0 \{K_1(K_1 \cos^2 \alpha + K_2 \sin^2 \alpha) + K_2(K_1 \sin^2 \alpha + K_2 \cos^2 \alpha)\} \qquad \text{(i)}$$

K_1, K_2 are respectively the transmission coefficients of the 'desired' and 'undesired' components and I_0 the initial intensity.

Considering $I_0 = I_1 + I'$ where I_1, and I' are respectively the intensities of the visible and infra-red components of I_0 and assuming that K_2 is negligible in I_1 and that in I', $K_1 = K_2 = K'$ one gets,

$$J = \frac{1}{2} K_1^2 I_1 \cos^2 \alpha + K'^2 I' \quad .. \quad .. \quad .. \quad \text{(ii)}$$

Equation (ii) shows that α affects only the visible component; very likely, it is this component which determines the magnitude of the corresponding light effect. Now the energy distribution of most of the familiar light sources is such that by far the major part of it lies in the infra-red, i.e. $K'^2 I'$ is the chief determinant of J. It is to be anticipated, therefore, that J–$\cos^2 \alpha$ should represent a straight line, whose segment $K'^2 I'$ should decrease on reduction of I'; that a complete elimination of

the visible should make J independent of α; and finally that J measured by methods sensitive to (I_1+I'), e.g. with a thermopile or photo-cell, should but little change with α.

33. On the use of a polaroid-pair as an intensity-variometer. Part II.

P. G. DEO *and* M. G. BALSUBRAMANIAN, Benares.

The nicol-like performance of a polaroid-pair has been investigated quantitatively for the range 0 to $\pi/2$ of α, the inter-polaroid angle using an incandescent bulb as a light source. The intensity-α variations were determined by using a Kipps 37, thermopile and R.C.A. caesium-coated photo-cell. The infra-red part which represented most of the incident energy was weakened progressively by water-filter, the thickness being increased up to 55 cms. Employing both the above methods, at constant thickness, the intensity–$\cos^2\alpha$ relation was linear, and this line tended towards the origin as the water-thickness was increased. Experiments were also made in which the incident beam was filtered through a saturated solution of iodine in carbon disulphide which absorbed the visible; the filtered intensity did not vary with α.

The ratio of the intensities at the cross and parallel axes position was zero for a nicol-pair; with the polaroids, however, it was about 0·97. If this is due to the invariance towards α of the infra-red, it is to be anticipated that this ratio would be larger in the infra-red than in the visible. This has been observed on filtration through the iodine-carbon bisulphide solution and also by eliminating the infra-red by a monochromator-like arrangement. The spectra of the transmitted beam showed a comparatively rapid fading at the short wave end, as α approached $\pi/2$.

34. Relative infra-red absorption capacity of water and aqueous iron ammonium sulphate.

P. G. DEO *and* M. G. BALASUBRAMANIAM, Benares.

The present work was undertaken in order to elucidate Forsyte's (*Phys. Rev.*, 1912, **34**, 333) observation that compared with water a solution of 'double sulphate of iron and ammonia' possessed a greater capacity for absorbing the infra-red. This was investigated by the observation of the intensity of a beam filtered through a crossed polaroid-pair (Pollard, *Nature*, 1936, **138**, 311). This enabled conveniently to eliminate almost in entirety the visible and the ultra-violet. It is considered that it is the ferrous ammonium sulphate which represents the significant absorbent. The greater absorptive capacity of its solution than that of water has been observed over a wide range of thicknesses of the absorbing columns. Data are also obtained for the influence of addition of KCl, NaCl and $CuSO_4$ on the corresponding transmissions determined both with a thermopile and spectroscopically.

35. Dielectric strength of chlorine under fields due to low frequency alternating potentials.

P. G. DEO *and* B. S. R. SASTRY, Benares.

The above quantity has been investigated by determinations of the minimum spark potentials characteristic of chlorine whose pressure is varied in the range 1 to 14 cm. Hg at room temperature. The electrodes are silver discs, coated with silver chloride, of about half a cm. diameter, and sealed in the discharge tube, which is connected to a stock of purified chlorine and a glass spoon manometer. One of the two electrodes

is earthed; the other is connected to the secondary of the transformer fed by A.C. Two series of observations have been made in which the inter-electrode distance is 7·8 and 14·8 cm. As is to be expected, this spark potential increases sensibly linearly by increasing the gas pressure except when the pressures are low. The dielectric strength of chlorine is found to be markedly higher than that for air under identical conditions, presumably due to the higher electron affinity of chlorine.

36. The influence of temperature on the light effect in chlorine.

P. G. DEO *and* H. A. PADMANABHULU, Benares.

Earlier studies (Joshi and Narasimhan, *Curr. Sci.*, 1937, **9**, 537. Joshi and Deshmukh, *Nature*, 1941, **147**, 806. Joshi and Deo, *ibid.*, 1943, **151**, 561) of the nature of this phenomenon have been restricted to the observation of the influence of nature of the gas, its pressure, the size of the discharge tube, and the intensity and frequency of irradiation. The present work reports results for the influence of temperature on the magnitude of the effect. It is seen that with a frequency of 50 cycles, applied potential varies in the range 1·3 to 6·7 kV, the light effect as indicated by Δi, the diminution of the discharge current on irradiation, remains sensibly constant over the temperature range 30° to 270°. The proportional diminution, i.e. $\Delta i/i$ decreases at high temperatures.

37. The influence of temperature on the new light effect in HCl gas under electrical discharge.

SUBBA RAO *and* SHANMUKHA RAO, Benares.

The results for the above phenomenon now observed in various gases (Joshi and Deshmukh, *Nature*, 1941, **149**, 806) under different conditions of excitation suggested the present work. As reported earlier by Joshi and Deshmukh (*loc. cit.*), compared with chlorine the light effect was low in the HCl gas. The present experiments have been carried out with a large ozonizer about 100 cm. in length which presented a larger area for irradiation and excited by a potential varied from about 2000–6600 volts r.m.s. The change in the corresponding current on irradiation is indicated by a reflection galvanometer actuated by a rectifier.

The pressure of the HCl gas is varied in the range from 10 mm. to 300 mm. Hg. The temperature is increased from 20° to 60°. It is found that at low pressures both i, the conductivity, and Δi, the light effect, that is the diminution of conductivity on irradiation increase by increasing the temperature. At higher pressure, however, Δi reaches a maximum at about 40° and tends to diminish at higher temperatures.

38. The influence of intensity on the new light effect in HCl gas under electrical discharge.

SUBBA RAO *and* SHANMUKH RAO, Benares.

The general mode of experimentation and the technique is similar to that followed in earlier work on the influence of temperature. In the following experiments the intensity of irradiation has been varied by altering the distance of the light source from the discharge tube. It is remarkable to observe that the light effect is quite perceptible when the light source is kept as much as over 4 meters distance from the ozonizer. The influence of intensity on the light effect has also been studied at various exciting potentials. In general the light effect diminishes by diminishing the intensity. This diminution is comparatively more rapid at about 60° than at about 25° in the pressure range 40 to 100 mm. Hg of the gas subjected to the discharge.

39. Decomposition of nitric oxide in the silent electric discharge. Part IV. Effect of temperature on the decomposition.

K. S. VISVANATHAN *and* T. P. SOUNDARA RAJAN, Benares.

Nitric oxide at different initial pressures ranging from 5 to 20 cm. of Hg has been subjected to a two-minute discharge at 5000 volts (r.m.s.) in a Siemen's ozonizer and the reaction products are then collected and analysed. Each reaction is carried out at four different temperatures, viz. 5°, 20°, 50° and 70°. Analysis of the decomposed products reveals the presence of undecomposed nitric oxide, nitrogen peroxide and nitrogen. As is to be anticipated the percentages of nitrogen peroxide and nitrogen increase while the percentage of undecomposed nitric oxide decreases with rise in temperature. In no case has nitrous oxide been detected. This is contrary to the results of Briner and Wroczynsky (*Compt. rend.*, 1909, **149**, 1372, 1518) on the decomposition of nitric oxide in a glow discharge.

In order to see whether nitrous oxide is formed at any stage in the course of the reaction, nitric oxide at a particular pressure and temperature has been subjected to discharges of varying time intervals. Analysis of the reaction products at the end of each discharge shows no evidence for the presence of nitrous oxide.

40. Decomposition of nitric oxide in the silent electric discharge. Part III. Influence of temperature on the rate of decomposition.

K. S. VISWANATHAN *and* T. P. SOUNDARA RAJAN, Benares.

With a view to study the effect of temperature on the rate of decomposition, nitric oxide at different initial pressures ranging from 4·7 cm. to 35·0 cm. of Hg has been taken in a Siemen's ozonizer and subjected to silent electric discharge at 5000 volts (r.m.s.), the reaction at each pressure being carried out at three different temperatures, viz. 20°, 50° and 70°. The data reveal that there is a considerable rise in the rate of decomposition consequent to the rise in temperature, which becomes more pronounced at higher concentrations. This is particularly remarkable in view of the fact that reactions in silent electric discharge are of the nature of high temperature reactions and it is not to be anticipated that a rise of few degrees should exert such a marked influence on the rate of the reaction. This observation is very interesting and suggestive as likely to afford an insight into the mechanism of reaction in the silent electric discharge.

41. Electrolysis of sodium chlorate.

D. N. SOLANKI *and* I. S. K. KAMATH, Benares.

The electrolytic oxidation of sodium chlorate in neutral aqueous solutions (40%) using platinum electrodes has been studied. At ordinary temperatures, 15°–20° and with equal anodic and cathodic current densities ranging from 15 amp./dm.^{2} to 50 amp./dm.^{2}, the current yield of the persalt formed is very high. The variation of anodic and cathodic current densities within the above range alters the C.E. but slightly. The addition of catalysts or addition agents like Na_2HPO_4 and NaF have very little effect on the C.E. probably because of the fact that the C.E. is high enough even in their absence. The C.E. for the duration of electrolysis equal to one hour is about 96% and does not fall off considerably up to four hours.

The oxidation products of $NaClO_3$, viz. the per salt is highly soluble in water and can be precipitated as the corresponding potassium per salt by double decomposition with a strong solution of KCl, advantage being taken of the fact that the potassium per salt is sparingly soluble in water.

42. Permanence of sorption-desorption hysteresis.

T. KRISHNAPPA, K. SUBBA RAO *and* B. SANJIVA RAO, Bangalore.

The effect of variation of temperature of precipitation of gels of hydrous oxides of silica, titania and alumina on the hysteresis effect in the sorption of water vapour has been studied at 30°. Gels have been obtained by precipitating the hydrous oxides at 25° and 100° with previous boiling.

In all the systems studied, the permanent hysteresis loops have been obtained. With increase in the temperature of precipitation there has been a diminution in the sorptive capacity of gels for water at different partial pressures and in the majority of systems, the hysteresis loop suffers a diminution in size with a change in the shape and position of the loop. But in none of these systems, is complete elimination of the loop noticeable. Gels precipitated at 100° are less porous than the gels precipitated at 25° and appear to have fewer cavities than are primarily responsible for the phenomenon of hysteresis.

43. Temperature of activation and the hysteresis effect. Silica gel—water system.

T. KRISHNAPPA, K. SUBBA RAO *and* B. SANJIVA RAO, Bangalore.

The effect of variation in activation temperature of silica gel on the hysteresis effect has been studied. Sorption and desorption of water vapour at 30° on gels activated at 35°, 70°, 140°, 300°, 500° and 1000° have been conducted. At all temperatures of activation, permanent and reproducible hysteresis loops have been obtained. There is, however, a marked variation in the total sorptive capacity and the area of the hysteresis loop.

The results indicate that from 35° to 140° there is a decrease in capillary space in the gel, from 140° to 500° the capillary space remains practically unaltered and above 500° the gel suffers structural change. The capillaries collapse with a marked decrease in the total capillary volume.

44. Mode of preparation of silica gel and its effect on sorption hysteresis.

T. KRISHNAPPA, K. SUBBA RAO *and* B. SANJIVA RAO, Bangalore.

A comparative study has been made with regard to the shape and size of the hysteresis loops obtained with silica gel prepared from (*a*) precipitated silicic acid, and (*b*) silicic acid jelly. The mode of preparation of the gel is found to greatly influence the shape and size of the hysteresis loop in sorption.

45. Studies on adsorption in relation to constitution. Part III. Adsorption of carbohydrates by active charcoal.

B. P. GYANI *and* P. B. GANGULY, Patna.

The adsorptions of arabinose, xylose, rhamnose, dextrose, fructose, mannose, galactose, maltose, sucrose and of α-methyl-*d*-glucoside from dilute aqueous solutions on active charcoal have been studied and discussed in relation to the constitution of the groups of molecules. A comparison of the adsorption data with the chemical properties leads to the conclusion that the attachment of the molecule to the adsorbent is even looser than in the formation of hydrates.

46. Studies on adsorption in relation to constitution. Part IV. Adsorption of organic vapours on silica gel.

B. P. Gyani *and* P. B. Ganguly, Patna.

The adsorption of a series of homologues of hydrocarbons, alcohols, esters and ketones on silica gel has been studied. A comparison of the adsorption data and physical properties like critical temperatures, dipole moments and constants of van der Waals' equation give definite indications of a relationship between adsorption and the constitution of the molecule.

47. Studies on metallized silica gel catalyst.

A. S. Chakravarti *and* P. B. Ganguly, Patna.

The reduction of nitric oxide to ammonia in presence of copper, silica gel as the catalyst has been investigated. The effects of temperature-rates of flow and the proportions of reacting gases have been determined. The reduction proceeds to an extent of 90–95% with a slight excess of hydrogen at a temperature of 250°.

48. Conditions in which chlorine is present in hydrous hydroxide sols.

B. P. Yadava *and* A. C. Chatterji, Lucknow.

The total chlorine, free and osmotically active chlorine, in the sols of Fe_2O_3, Al_2O_3, and Cr_2O_3 have been determined. The sols have been coagulated by KNO_3, K_2SO_4, and K-citrate and the release of chlorine ions on coagulation has also been measured.

It has been found that in an impure sol the amount of secondarily adsorbed chlorine ions is large, and this quantity decreases as the purity of the sol increases.

49. The effect of dilution on the displacement of chlorine ions from $Fe(OH)_3$ sol by stepwise addition of electrolytes.

B. P. Yadava, Lucknow.

The effect of diluting $Fe(OH)_3$ sol on the release of the counter ions has been studied when the colloid is coagulated by KIO_3, K_2SO_4, and K-citrate. E.M.F. measurements have been employed to measure the release of chlorine ions.

From the results recorded a general tendency can be observed that there is a decrease in the release of chlorine ions on dilution. This is due to a decrease in the concentration of the colloid and a subsequent decrease in the release of chlorine ions.

50. The study of the displacement of chlorine ions from $Fe(OH)_3$ and $Cr(OH)_3$ sols by potentiometric titration method.

B. P. Yadava, Lucknow.

The release of chlorine ions from $Fe(OH)_3$ and $Cr(OH)_3$ sols has been studied in order to find out if an insight into the mechanism of coagulation by electrolyte pairs can be obtained. Electrolyte pairs like KIO_3–K_2SO_4, KIO_3–K-citrate, and K_2SO_4–K-citrate have been used. Along with this the release of chlorine from KIO_3, K_2SO_4 and K-citrate when added singly is also recorded in order to enable us to calculate the theoretical release due to the combined action of the two electrolytes. When $Fe(OH)_3$ is titrated by single electrolytes the amount of chlorine displaced increases when KIO_3 is replaced by K_2SO_4 but with higher valency coagu-

lating ions such as K-citrate it again decreases, whereas with $Cr(OH)_3$ the displacement of chlorine ions is almost the same with all the electrolytes. This can be explained on the basis of the purity of the sols.

With these sols the amount of released chlorine is generally greater than the calculated value, indicating that the mixture induces more instability than that produced by the same electrolytes acting singly.

51. Kinetics of coagulation of As_2S_3 and $Fe(OH)_3$ sols with and without the addition of non-electrolytes.

B. P. Yadava *and* A. C. Chatterji, Lucknow.

The kinetics of coagulation with As_2S_3 and $Fe(OH)_3$ sols in presence of non-electrolytes have been studied in order to find out if sensitization or protection produces any difference in the velocity of coagulation of these sols. The method due to Paine (*Koll. Chem. Beihefte*, 1914, **4**, 24) has been utilized to follow the progress of coagulation in the slow region.

It has been found that β, the velocity constant, remains almost constant in the case of As_2S_3 sol when no non-electrolyte is added. When methyl alcohol, ethyl alcohol, sugar, are added there is, however, a slight tendency for β values to increase with time whereas with gelatine and agar-agar there is a slight tendency to decrease. Moreover, with methyl alcohol the β values increase when the concentration of the non-electrolyte increases for the same time intervals whereas with other non-electrolytes the β values decrease.

With $Fe(OH)_3$ sol the β values show a tendency to fall with time in the case of all non-electrolytes for any particular concentration of these non-electrolytes, but in this case also it is found that when the quantities of the non-electrolyte are increased, with methyl alcohol β increases for the same time interval and decreases with other non-electrolytes.

52. Study of ionic antagonism by the potentiometric titrations of arsenious sulphide sol.

B. P. Yadava, Lucknow.

The adsorption of chlorine ions from KCl, NaCl, NH_4Cl, $BaCl_2$, and $AlCl_3$, when these electrolytes are taken single, and in pairs, has been studied by E.M.F. method.

It has been observed that with certain pairs like $KCl + BaCl_2$ the observed adsorption of chlorine ions is greater than the calculated value, while in other pairs such as $NaCl + KCl$, $KCl + NH_4Cl$, no increase in the adsorption of chlorine ions is observed. It is believed, therefore, that ionic antagonism observed in this case is also, as in the cases previously studied, due to the greater adsorption of similarly charged ions when one electrolyte is added in presence of the other.

53. Properties of 'aged' synthetic mixtures of colloidal silicic acid and aluminium hydroxide.*

B. Chatterjee, Calcutta.

The free and total acidities and forms of potentiometric titration curves with NaOH of two synthetic mixtures of colloidal aluminium hydroxide and silicic acid having SiO_2/Al_2O_3 ratios of 2 : 1 (mixture I) and 4 : 1 (mixture II) have been determined. These mixtures had been allowed to age for a year and a half before making the measurements. The titration curve of colloidal silicic acid shows an inflexion point at

* The work has been carried out under a scheme financed by the Imperial Council of Agricultural Research, and directed by Prof. J. N. Mukherjee.

about pH 5·0 and another between pH 11·0 and 12·0 depending upon the concentration of silica in the sol. (Chatterjee, *J.I.C.S.*, 1939, **16**, 589.) Colloidal aluminium hydroxide (aged) gives an inflexion point at about pH 12·5. (Datta, *J.I.C.S.*, 1939, **16**, 573.) In the case of the mixtures the titration curves show two inflexion points, the first at pH 5·4 and 5·0 for mixtures (I) and (II) respectively and the second at pH 7·0 for both the mixtures. Both the free and total acids at either inflexion point increase with the SiO_2/Al_2O_3 ratio of the mixture. An interaction between colloidal silicic acid and aluminium hydroxide has been suggested.

54. Diminution of the pH values of suspensions of some Indian soils in normal potassium chloride solution.*

S. K. Nandi, Calcutta.

pH values of suspensions of two acid soils and three calcareous soils in water and in normal potassium chloride solution have been measured using the glass and quinhydrone electrodes and by Kuhn's colorimetric method. Results obtained by the glass electrode are somewhat lower than those obtained by the other two methods. The pH values of the soils are lower in potassium chloride solution than in water. This is to be expected in the case of acid soils. In the case of calcareous soils also which have pH values greater than 8·0 as measured by the glass electrode, the pH values are lowered in one case from 8·2 to 7·0 and in another case from 8·1 to 6·9. An explanation of this apparently unusual behaviour of calcareous soils has been put forward.

55. On the mechanism of filtration of concentrated clay suspensions.

N. C. Sen-Gupta *and* M. M. Dey, Calcutta.

It has been shown elsewhere that when concentrated clay suspensions are filtered through filter paper or sand beds it can be deduced from Darcy's relation (with certain assumptions) that at constant temperature and pressure the cumulative volume of filtrate collected in a given time is proportional to the square root of the time since pressure is applied. When the filtration is continued for a much longer period, however, a deviation from the square root relation is observed, and ultimately the cumulative volume of filtrate tends to vary directly as the time of filtration. A number of clay suspensions having different colloid contents and a bentonite suspension show the same type of behaviour.

The moisture content of different sections of the filter cake has been found to vary regularly with the thickness of deposition. The percentages of clay and silt generally reach a maximum round about the middle portion of the cake. Sand content varies with the thickness of the cake. An explanation of the observed variation of filtration rate with time is put forward.

56. Properties of freshly precipitated and aged alumino-silicates.

S. P. Raychaudhuri, Dacca.

Nine types of alumino silicate gels have been prepared by mixing different proportions of aluminium hydroxide and silicic acid sols in three different ways, viz.: (1) by slowly adding silicic acid sol to an excess of aluminium hydroxide sol; (2) by slowly adding aluminium hydroxide sol to an excess of silicic acid sol, and (3) by mixing the two sols dropwise. The properties of these nine types of precipitates have been determined.

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* The work has been carried out under a scheme financed by the Imperial Council of Agricultural Research, and directed by Prof. J. N. Mukherjee.

Experiments are carried out also with electrodialyzed alumina and silica gels as also with the naturally occurring minerals, montmorillonite, halloysite, kaolin, quartz and bauxite. The general conclusions which are brought out from the results are that the heating of the precipitated alumino-silicates changes their structure in such a manner that their base exchange capacities increase and their general properties tend to approach the properties of natural minerals. It also appears that mixing the colloidal solutions of aluminium hydroxide and silicic acid dropwise favours the formation of mineral structure.

57. A comparative study of sieve analysis, sedimentation and microscopic methods of measuring particle size.

J. N. Mukherjee *and* N. C. Sen-Gupta, Calcutta.

For spherical particles microscopic and sedimentation measurements should give the same particle diameter, and in the sieve analysis a definite relation exists between the sieve aperture and particle size. For non-spherical particles, however, the three methods give different particle sizes. In view of the influence of particle size on packing, porosity, permeability, etc., of consolidated or unconsolidated powders, comparisons of different methods of measuring particle size have been undertaken. Preliminary measurements using three different fractions of a fine sand separated by sedimentation in a sugar solution of viscosity 3·03 cp. show that the shorter of two microscopic dimensions at right angles, averaged over two hundred particles are 31·4, 46·7 and 61·7μ, while average equivalent diameters calculated from sedimentation velocity are 25, 35 and 45μ respectively. The ratios between the microscopic and sedimentation diameters are 1·29, 1·33 and 1·37 respectively. Microscopic measurements have also been made with a sand fraction passing through a square sieve when dry but retained when wet. The sieve aperture is 85μ and the microscopic diameter measured in the above way is 103·9μ the ratio being 1·22.

58. Decomposition of ammonium molybdate with hydrochloric acid and caustic soda.

A. B. Biswas, Bangalore.

The decomposition of ammonium molybdate with HCl and NaOH has been studied potentiometrically with glass electrode and conductometrically in the usual manner of titration. It has been found that ageing or boiling has no effect on the nature and extent of the curve. In the case of HCl the behaviour of the salt is the same as sodium molybdate studied by various workers in that the salt is decomposed to the extent demanded by the formula $(NH_4)_2O$, 5-6MoO_3, and thereafter the titration curve indicates as if free HCl acid is present. With NaOH it is found that $\overset{+}{NH_4}$ ion can be quantitatively displaced and from the middle region of the curve the percentage of $\overset{+}{NH_4}$ ion present in the original salt can be calculated. The value agrees fairly with Kjeldahl method of estimation of NH_3.

59. Photo-reduction of ferric chloride in presence of organic substances in aqueous and non-aqueous media.

Mata Prasad *and* P. R. Bavdekar, Bombay.

Photo-reduction of ferric chloride in presence of various organic substances, such as organic acids, sugars, ether and acetone, has been studied in aqueous and, in some cases, non-aqueous media, using the ceric sulphate method for the estimation of the amount of reduction. The reaction

is zero-molecular in the case of organic acids and sugars, uni-molecular in the case of ether and aqueous acetone and of an inhibited type in the presence of anhydrous acetone. An increase in the temperature and the frequency of the exciting radiations has in all cases an accelerating effect on the velocity constant of the reaction. The velocity constant of the reaction is in all cases directly proportional to the intensity of the incident light. The quantum efficiency of the reaction increases with dilution of ferric chloride, temperature and frequency of the exciting radiations and is of the order of 0·5 in case of organic acids, sugars and aqueous acetone, nearly unity in ethereal solutions and greater than one in presence of anhydrous acetone.

60. The photochemical reduction of ferric chloride in light of different frequencies in medium of thorium phosphate gel.

J. C. GHOSH *and* S. K. BHATTACHARYYA, Bangalore.

The kinetics of the reduction of ferric chloride by mandelic acid in light of frequencies 366 and 436 $\mu\mu$ in medium of transparent and colourless thorium phosphate gel have been studied. The reaction is found to be zero molecular and the velocity constant is found to increase with increasing concentrations of ferric chloride and in fact $\frac{\Delta x/\Delta t}{I_{\text{abs.}}}$ is found to remain constant for a particular wavelength which increases with increase in the magnitude of the quanta absorbed. The velocity constant also increases with increasing concentration of mandelic acid and is directly proportional to the intensity of absorbed radiation. The quantum efficiency is found to be very low. The results are compared with those obtained in media of thorium phosphate sol before gelation and of water. The rate of reaction is found to be the same in both sol and gel states of thorium phosphate but in water it is considerably greater. The extinction coefficients of ferric chloride in presence of excess mandelic acid have been measured in all the three media. A mechanism has been suggested.

61. Susceptibilities of $Ca^{\cdot\cdot}$ and $Sr^{\cdot\cdot}$ ions in heteropolar salts of organic and inorganic acids.

MATA PRASAD, S. S. DHARAMATTI *and* S. V. GOKHALE, Bombay.

The molecular susceptibilities of a number of calcium and strontium compounds of both organic and inorganic acids in a pure state have been measured by a modified form of Guoy's balance. The observed experimental values have been compared with those obtained by previous investigators as well as with those expected from Bhatnagar's theory of electronic isomers. The experimental data are utilized to calculate the ionic susceptibilities of $Ca^{\cdot\cdot}$ and $Sr^{\cdot\cdot}$ assuming the law of approximate additivity and making use of the values of the various anions given by previous workers.

The ionic values thus obtained have been compared with those calculated theoretically by Slater's and Angus' methods. These results have also been examined from the view-point whether there are any systematic differences between the values obtained from organic and inorganic salts as is found in the case of $Ba^{\cdot\cdot}$. The ionic radii of $Ca^{\cdot\cdot}$ and $Sr^{\cdot\cdot}$ have been estimated from the corresponding ionic susceptibilities and these values are compared with the data obtained by other methods.

62. A new law of dipole moments of polyatomic molecules.

S. K. K. JATKAR, Bangalore.

In the present paper certain difficulties in the interpretation of dipole moments of polyatomic compounds have been solved by a simple postulate

that the molecule is polarized along the axis of each bond; the observed dipole moment is the average of each of the bond moments with the components of the other bonds calculated along the connecting links. *Dipole moments are inductively affected by components and then add up vectorially for rigid and not in flexible molecules.* The bond moments calculated according to the new law proposed and using theoretical angles possess values which agree with those calculated from the product of internuclear distance and electronic charge taking account of the resonance in the molecule.

63. Dielectric constant of liquids and solids and dipole moments.

S. K. K. Jatkar, Bangalore.

It has been shown that the molar electric susceptibility of liquids $(\epsilon-1)\times M/D-P_E=\frac{4\pi N\mu^2}{kT}$ where ϵ is the dielectric constant of the pure liquid and μ its moment. The derivation of this follows if E, the internal electric force on a charge e within a needle-shaped cavity whose axis is parallel to E, is equal to the applied field F and the orientations are distributed according to Boltzmann's law not $u^2F/3kT$, but u^2F/kT which follows from the behaviour of the dipole in an electrical field postulated above. This relationship is found to hold good for all liquids from HBr ($\cdot 8D$) to nitrobenzene ($4{\cdot}2D$) and for solids which show molecular rotation. In the case of associated liquids kT is $\frac{1}{2}$. In ionic crystals the moment is inversely proportional to co-ordination number.

64. Electric polarization of binary liquid mixtures.

S. K. K. Jatkar *and* (Mrs.) Nagamani Kulkarni, Bangalore.

The failure of the Debye equation for the polarization of binary mixtures is too well known. The authors have applied the expression for molar susceptibility developed above to the different types of polarization curves of binary mixtures. The new values of molar susceptibility are either constant or are linear function of concentration, from which the dipole moment in dilute solutions could be deduced.

65. The dielectric constants and dipole moments of solids.

S. K. K. Jatkar *and* N. V. Sathe, Bangalore.

The relationship $(\epsilon-1)\ M/D-P_E=\frac{4\pi N\mu^2}{kT}$ developed by one of us (S. K. K. Jatkar) was used to interpret the high dielectric constant of the halides of hydrogen, lithium, sodium, potassium, rubidium, cesium, calcium, strontium, barium, magnesium, cadmium, silver, mercury and lead and oxides of copper, silver, mercury, lead, zinc, tin, iron, aluminium, silica, titanium, zirconium, chromium, antimony and magnesium in the solid state.

The dipole moments so calculated are of the same order magnitude as those for hydrogen halides in the pure liquids and gases and in dilute solutions. In the case of other solids the dipole moments multiplied by the co-ordination number are in close agreement with the values obtained by the molecular beam method and the theoretical bond moments. The significance of these results has been discussed in relationship to the structure of the solids.

66. Feeble paramagnetism of chromium trioxide and alkali chromates.

D. S. DATAR *and* S. K. K. JATKAR, Bangalore.

In the crystal of chromium trioxide Brakken has shown that with six oxygen atoms, chromium forms a somewhat deformed octahedral structure. One of us (Jatkar) postulated an uncoupled state of molecules to explain electric moments of molecules. The uncoupled state of a free oxide molecule is $\frac{1}{2}$, and in solids $1/n$ of this value where n is the co-ordination number. Thus for octahedral solid oxide CrO_3 the uncoupled state of Cr is $\frac{1}{2} \times \frac{1}{8} = \frac{1}{16}$. From the possible resonating structures and the magnetic data, it has been shown that $\frac{1}{16}$ gm. mol. of chromium trioxide and the chromates contribute towards paramagnetism.

67. The feeble paramagnetism of some oxides.

D. S. DATAR *and* S. K. K. JATKAR, Bangalore.

The uncoupled state of MO_3, WO_3 and UO_3 has been found to be 1/16, as in the case of CrO_3, 1/36 for TiO_2, 1/64 for SrO and BaO, 1/96 for Al_2O_3, and 1/128 for BeO, CdO, HgO and CaO. These fractions are connected with resonance structures and co-ordination number as in the case of the dielectric constant and dipole moments of solids.

68. Liesegang phenomena in rubber latex.

GEORGE T. VERGHESE *and* M. A. GOVINDA RAU, Bangalore.

A number of periodic phenomena have been observed and reported in the case of systems both in the gel state and in the sols, but only few observations have been made on periodic gel formation itself. We had occasion to study the behaviour of rubber latex on coagulation, and we came across the interesting phenomena of Liesegang ring formation in rubber gels. Another well-known phenomenon, viz. the formation of 'close spaced microscopic rings' has also been discovered in rubber gels.

A quantitative study of these coagulation phenomena is in progress which is expected to be of interest both for rubber latex work, as also for the theory of Liesegang ring formation.

69. Viscosity measurements of some soap gels in pinene.

MATA PRASAD *and* G. S. HATTIANGDI, Bombay.

The viscosities of gels of sodium palmitate, potassium stearate and potassium palmitate in pinene have been measured at various temperatures during the process of gelation. The viscosities were determined by the Falling Sphere method and were calculated from the modified equation of Stoke's law, wherein the corrections for the wall and end effects have been applied.

The results obtained for the three different soaps are very similar in general nature. They do not show any irregular changes of viscosity with time during the process of gelation.

The curves obtained on plotting log $(\eta-\eta_0)$ against 't' are straight lines for all the soap systems studied, which shows that the relation $\eta-\eta_0 = ae^{kt}$ is applicable to the process of gelation of these soaps in pinene.

The values of 'k' for solutions of the same concentrations have been calculated for different temperatures for the different soap-gels and it is found that the values of 'k' for solutions of the same concentrations, decrease as the temperature at which the viscosity measurements are taken, are increased.

70. Studies in some inorgano-organic gels in non-aqueous media.

MATA PRASAD *and* G. S. HATTIANGDI, Bombay.

The time of setting of gels of sodium oleate and sodium stearate in xylene, toluene and nujol, containing different amounts of the soaps have been measured by Fleming's method at several temperatures. For any temperature, the time of setting decreases rapidly at first and then gradually as the amount of the gel-forming substance in the mixture is increased; also, the time of setting of the various gels containing the same amounts of the soaps decreases as the gel-forming solutions are allowed to set at lower temperatures.

The curves obtained on plotting log t against the reciprocal of the absolute temperature ($1/T$) are sets of parallel straight lines in almost all cases. Values of the heat of activation (Q) of the gels, calculated from Hurd and Letteron's extension of Arrhenius' equation, are found to be independent of the soap contents within the range studied.

The time of setting of gels containing the same amount of the soap on cooling to the same temperature, changes with the nature of the solvent in which the soap is dissolved, the order being toluene > nujol > xylene.

Gels of several metal soaps like nickel stearate, cobalt stearate, chromium stearate, etc. have been prepared in several non-aqueous media, and their various properties are being studied.

71. Size of the gel particles.

MATA PRASAD *and* S. GURUSWAMY, Bombay.

The depolarization factors (ρv, ρh and ρu) of the light scattered by gels of thorium molybdate, thorium arsenate and silicic acid prepared by mixing different amounts of the gel-forming constituents have been studied. In general, the values of ρh are very high suggesting that the size of the particles of the gel even after it has set is less than the wave-length of light. An approximate estimate of the size of the particles has been made by comparing the intensity of light scattered at 45° and 135° to the incident light and it has been inferred that the size of the particles is about $\frac{1}{4}\lambda$. It has been pointed out that hydration produces no change in scattering and hence the actual size of the gel particles may be greater than $\frac{1}{4}\lambda$.

The applicability of Krishnan's relation $\rho u = \left(1+\frac{1}{\rho h}\right) / \left(1+\frac{1}{\rho v}\right)$ to the measurements of ρv, ρh and ρu of the above-mentioned gels has been confirmed by a good agreement between the experimental values of ρu and those calculated from the observed values of ρv and ρh.

72. Changes of the anisotropy and density scattering during gelation.

MATA PRASAD *and* S. GURUSWAMY, Bombay.

The changes in the intensity and depolarization factors (ρv, ρh and ρu of the transversely scattered light taking place during and after the gelation of thorium molybdate, thorium arsenate and silicic acid gels have been studied. The gels investigated belong to two classes: (a) those that decrease (thorium molybdate), and (b) those that increase (thorium arsenate and silicic acid) in opacity during gelation. It has been found that the density scattering in both the type of gels increases during gel-formation.

The anisotropy scattering increases during the formation of (b) type of gels but decreases in the case of (a) type. In the latter case in

the early stages of gel-formation the anisotropy scattering dominates over the density scattering and it decides the final observed changes in the intensity of scattered light.

73. Studies on gum jeol.*

M. K. INDRA *and* N. MAITRA, Calcutta.

Viscous properties of the gum from *Lannea Grandis* (locally known as jeol plant) and the corresponding gum acid have been investigated. The viscosity of this gum like those of similar gums increases more than linearly with the concentration. At corresponding concentrations the gum acid has lower viscosities than those of the gum itself. In the case of the gum an yield value appears at a concentration round about 0·6%, but in the case of gum acid yield value appears at a much higher concentration in the vicinity of 5·5%. The gum acid at a concentration of 2·8% has a *p*H 2·8. When titrated with caustic soda solution the titration curve shows two inflexion points and the corresponding buffer capacity curve two minima at *p*H 5·8 and 8 and a well-defined maximum at *p*H 6·6. The viscosity curve when plotted against corresponding *p*H values passes through a maximum about *p*H 6·2. This maximum appears to be related to the maximum of the buffer capacity curve.

74. Photo-reduction of dichromate by tartaric acid in the ultra-violet.

T. L. RAMA CHAR, Bangalore.

The photo-reduction of potassium dichromate by potassium tartrate has been studied in the ultra-violet region ($\lambda = 3130$Å). The reaction is zero-molecular with respect to dichromate. The velocity of the reaction is proportional to the intensity of ultra-violet light absorbed and the quantum efficiency of the photo-process is of the order of 0·1. *d*- and *l*-circularly polarized light give the same value for the velocity of the reaction. A mechanism, which can explain the above features, has been postulated for the photo-process.

75. Alcoholysis of oils and fats.

K. R. THAKAR *and* S. K. K. JATKAR, Bangalore.

The kinetics of alcoholysis of oils in presence of various catalysts have been followed by increase in the weight of non-volatile components of the reaction mixture and compared with the results obtained by the physical properties of the alcoholyzed oils such as density, refractive index, viscosity, dielectric constant, and saponification value. The method is rapid and accurate.

76. Effect of surface-active agents on indicators.

T. KRISHNAPPA, K. S. GURURAJA DOSS *and* B. SANJIVA RAO, Bangalore.

There is an apparent shift towards the acid side in the *p*H of buffered solutions as measured by the use of the indicators, thymol blue and bromphenol blue, when wetting agents like Igepon T and Nekal BX are present in the system. Igepon T shows a very large shift with thymol blue. Under favourable conditions the shift may be as large as 2·4 units, an effect much bigger than what has been reported in literature so far,

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* The work has been carried out under a research scheme financed by the Assam Oil Company under the direction of Prof. J. N. Mukherjee.

for any system; Nekal BX shows less of the pH shift. Both the wetting agents affect bromphenol blue to a smaller extent. A quantitative investigation of the phenomenon has been made. A theory has been put forth based on the formation of a complex between the wetting agent and the indicator to account quantitatively for the effect of concentration of the wetting agent on the pH shift. Igepon T shows a marked shift with bromphenol blue as well. This forms a clear exception to the sign rule of Hartley. Increase in ionic strength decreases the pH shift with thymol blue as it is the case with the system worked by Hartley and Roe. When bromphenol blue is used, neutral salts produce an opposite effect. An explanation is offered which accounts for these diverse results. The variation of pH shift with concentration of Nekal BX with thymol blue indicates that micelle formation of the wetting agent occurs rather suddenly. The possible relationship between the pH shift and wetting power is pointed out.

Organic Chemistry

77. Mercuration of some nitro and halogen derivatives of 2-hydroxy-4-methoxy-benzaldehyde.

S. Venkata Rao *and* H. Subba Jois, Bangalore.

The following acetoxy-mercuri compounds have been isolated:—

(1) 2-Hydroxy-3-nitro-4-methoxy-5-acetoxy mercuri-benzaldehyde from 2-hydroxy-3-nitro-4-methoxybenzaldehyde (m.p. 220°, decomp.).

This on bromination gives 2-hydroxy-3-nitro-4-methoxy-5-bromo-benzaldehyde. On iodination it gives 2-hydroxy-3-nitro-4-methoxy-5-iodo-benzaldehyde (m.p. 102°; oxime, m.p. 156°; hydrazone, m.p. 155°).

(2) 2-Hydroxy-3-acetoxymercuri-4-methoxy-5-nitro-benzaldehyde from 2-hydroxy-4-methoxy-5-nitro-benzaldehyde (m.p. 260°, decomp.).

On bromination it gives 2-hydroxy-3-bromo-4-methoxy-5-nitro-benzaldehyde. On iodination it gives 2-hydroxy-3-iodo-4-methoxy-5-nitro-benzaldehyde (m.p. 128°; oxime, m.p. 209°; phenylhydrazone, m.p. 193°).

(3) 2-Hydroxy-3-acetoxymercuri-4-methoxy-5-chloro-benzaldehyde from 2-hydroxy-4-methoxy-5-chloro-benzaldehyde (decomposes at 250°).

On bromination it gives 2-hydroxy-3-bromo-4-methoxy-5-chloro-benzaldehyde. On iodination it gives 2-hydroxy-3-iodo-4-methoxy-5-chloro-benzaldehyde (m.p. 103°).

78. Studies on the formation of the Grignard reagent.

S. H. Zaheer *and* S. A. Faseeh, Lucknow.

From a study of about nineteen substituted halogen derivatives of benzene, it has been observed that compounds with a larger dipole moment than 2×10^{-18} e.s.u. show no tendency to form Grignard reagent in ethereal solution; while compounds with a lower value react to yield the magnesium complex in the inverse order of their dipole moments.

All the different constitutional formulae assigned to this compound give it a covalent structure. The results of the above experiments are in agreement with the general observation that the lower the value of the dipole moment of a compound the greater is its tendency to produce co-valent compounds.

Fluorobenzene and chlorobenzene, in spite of their having a low dipole moment fail to react with magnesium in ethereal solution. This may be explained on the basis of Fajan's theory of deformation of ions. This difficulty is removed with the introduction of a second chlorine atom in the benzene nucleus, both *para-* and *meta-*chlorobenzenes giving good yields.

79. Studies in long-chain acids. Part V.

P. C. MITTER and M. C. SEN-GUPTA, Calcutta.

Aleuritic acid can be converted to epi-ambrettolic acid (I) by the method of Mitter and Bhattacharya (*J.I.C.S.*, 19, 69). When the ester of (I) is brominated and then oxidized with chromic acid under controlled conditions, the half ester of 8 : 9-dibromotetradecane-1 : 14-dicarboxylic acid is obtained. This on debromination gives half ester of Δ^{8}-tetradecane-1 : 14-dicarboxylic acid which on Bouveault reduction is expected to give ambrettolic acid.

80. Synthesis of 5 : 6-methylenedioxy-phthalaldehydic acid.

S. N. CHAKRAVARTI, Agra.

5 : 6-Methylenedioxy-phthalaldehydic acid, for the synthesis of which numerous attempts have been made including one by Perkin and Trikojus, has been synthesized in the following manner:—

5 : 6-Methylenedioxy-homophthalic acid, synthesized by an improved method, is oxidized in boiling xylene solution by means of selenium dioxide to 5 : 6-methylenedioxy-phthalonic acid which is converted into 5 : 6-methylenedioxy-phthalaldehydic acid (I), m.p. 155°, through its sodium bisulphite compound. This acid (I) gives on reduction 5 : 6-methylenedioxy-phthalide, m.p. 227° and starting from this important acid cryptopine and protopine have been synthesized.

81. On the constitution of castelamarin.

(MISS) K. D. PARANJAPE, N. L. PHALNIKAR, B. V. BHIDE and K. S. NARGUND, Poona.

Castelamarin, the bitter principle isolated from *Castela Nicholsoni*, has been formulated as the lactone of 3-methoxy-2-hydroxy-*cyclo*hexane-acetic acid by Bosman (*J.C.S.*, 1922, 970). The present paper describes the synthesis of this lactone by the following reactions:—

Condensation of 6-keto-2-chloro-$\Delta^{1,2}$ *cyclo*hexane (Crossley, *J.C.S.*, 1903, 484) with diethyl sodio malonate, followed by hydrolysis gives the lactone of 3-keto-2-hydroxy-*cyclo*hexane-acetic acid. Reduction of this keto-lactone followed by methylation with diazomethane affords the lactone of 3-methoxy-2-hydroxy-*cyclo*hexane-acetic acid (m.p. 79°). This lactone is not bitter and is easily demethylated to the corresponding hydroxy lactone. A comparison of the properties of the lactone with those of castelamarin (m.p. 265°) shows no similarity. Castelamarin, therefore, cannot have the structure of lactone of 3-methoxy-2-hydroxy *cyclo*hexane-acetic acid.

82. Synthesis of analogues of santonin.

(MISS) K. D. PARANJAPE, N. L. PHALNIKAR, B. V. BHIDE and K. S. NARGUND, Poona.

Recently we have reported the synthesis of santonin (*Current Science*, 1943, 153). This paper describes the synthesis and properties of some analogues of santonin using similar reactions.

These lactones differ from santonin in the fact that they contain one or two methyl groups less than santonin. The pharmocological action of these lactones has been studied.

83. The coupling of diazo salts with phenolic ketones.

R. J. PHADKE and K. VENKATARAMAN, Bombay.

Resacetophenone couples with diazo salts to form the 3-azo dyes, indicating the fixation of double bonds on account of chelation between

the ketonic and *o*-hydroxyl groups. By the reduction of the azo dyes with zinc and acetic acid 3-aminoresacetophenone has been prepared. The aminophenol gives an *o*-quinone by oxidation with dichromate and sulphuric acid, reduction of the *o*-quinone with zinc and acetic acid leading to gallacetophenone. The constitution of benzeneazoresacetophenone has been confirmed. When resacetophenone is converted into the chalkone, 2 : 4-dihydroxyphenyl styryl ketone, chelation between the *o*-hydroxyl and ketonic groups is apparently weakened as a result of the conjugation of the carbonyl and styryl double bonds, so that the chalkone resembles resorcinol, rather than resacetophenone, in its reactivity towards diazo salts. Thus coupling with diazotized 2 : 5-dichloraniline gives the *disazo* dye.

Studying 2-acetylresorcin and 2 : 5-dihydroxyacetophenone similarly, it has been found that chelation and consequent fixation of double bonds are shown by the formation of 4-benzeneazo-2-acetyl resorcin and 6-benzeneazo-2 : 5-dihydroxyacetophenone respectively. From both these azo dyes, following the series of reductions, oxidations and reductions mentioned earlier, 2 : 5 : 6-trihydroxyacetophenone is obtained. This is a new trihydroxyacetophenone, likely to be of interest for synthesis in the flavone series.

84. A new synthesis of 5 : 6-dihydroxyflavone.

R. J. Phadke *and* K. Venkataraman, Bombay.

The coupling of 6-hydroxyflavone with diazobenzene chloride and diazotized 2 : 5-dichloraniline gives respectively dyes formulated as 5-benzeneazo-6-hydroxyflavone (I) and 5-(2′ : 5′-dichloro)benzeneazo-6-hydroxyflavone. By reduction of (I) 5-amino-6-hydroxyflavone is obtained, which has been oxidized to the *o*-quinone (flavone-5 : 6-quinone). The quinone is then reduced to the dihydric phenol, identified as 5 : 6-dihydroxyflavone.

Repeating the reactions with 5-hydroxyflavone, the azo dyes are found to be the 6-benzeneazo derivatives. Reduction gives 6-amino-5-hydroxyflavone, which could be easily oxidized to a quinone identical with the quinone obtained from 6-hydroxyflavone. Reduction of the quinone leads to 5 : 6-dihydroxyflavone, which could thus be prepared from 5- or 6-hydroxyflavone as starting material. Since the yield of 6-benzeneazo-5-hydroxyflavone isolated in pure form by repeated crystallization is low, it is probable that the 8-benzeneazo isomer is also formed during coupling. Attempts are in progress to separate and characterize it, so that a new synthesis of primetin may be effected.

85. The hydroxyanthracenes and anthraquinones as coupling compounds.

K. I. Narsimhan, S. R. Ramachandran *and* K. Venkataraman, Bombay.

The present work records preliminary experiments on modifications of the constitution of alizarin with a view to develop more expeditious dyeing properties. In the first instance, the coupling of alizarin with diazo salts was studied. With diazobenzene chloride and other salts of low coupling energy, alizarin did not couple, but with diazotized 2 : 5-dichloraniline, *p*-nitraniline and *o*-dichlorobenzidine, the 3-azo derivatives were obtained. Further, while 4-bromo- and 4-aminoalizarin coupled with diazotized dichloraniline, the 3-substituted analogues, as well as 3-benzoylamidoalizarin, were unreactive. Quinizarin did not couple, while xanthopurpurin coupled in neutral alcoholic solution. α- and β-Hydroxyanthracene exhibited normal behaviour as secondary components, but the hydroxyanthraquinones did not couple with diazo salts under the conditions so far investigated. 2-Hydroxyanthracene-3-carboxylic acid, prepared by the hydrolysis of Naphtol AS-GR, coupled

very readily with diazo salts; and in contrast to β-hydroxyanthraquinone, 2-hydroxyanthraquinone-3-carboxylic acid, prepared by the oxidation of 2-hydroxyanthracene-3-carboxylic acid, also responded to the coupling reaction. Oxidation of Naphtol AS-GR to the corresponding anthraquinone did not destroy its coupling power. The theoretical basis of these observations is discussed.

86. A synthesis of 4-bromoalizarin.

K. I. NARSIMHAN *and* K. VENKATARAMAN, Bombay.

Bromination of alizarin 2-*p*-toluene sulphonate has yielded the 4-bromo derivative, which is hydrolyzed by hot concentrated sulphuric acid to 4-bromoalizarin, m.p. 243-244°, the constitution of which is confirmed by its partial methylation to its 2-methyl ether, m.p. 234-235°, and by its ability to couple with diazo salts. The action of *p*-toluenesulphonyl chloride on alizarin gives exclusively the 2-*p*-toluene sulphonate.

4-Bromoalizarin is different in properties from *x*-bromoalizarin, obtained by heating *x*-*x*-*x*-tribrom-anthraquinone, m.p. 186°, with caustic soda at 180°, and described as a red-brown substance melting above 280° (Diehl, *Ber.*, 1878, **11**, 190). It is also different from 3-bromoalizarin prepared by previous workers. 3-Bromoalizarin does not couple with diazo salts.

87. Lauryl-*p*-toluidide-2-sodium sulphonate as an outstanding wetting agent.

E. D. DARUWALA, B. D. TILAK *and* K. VENKATARAMAN, Bombay.

Lauryl-*p*-toluidide-2-sodium sulphonate (I) has been obtained by condensing lauryl chloride with *p*-toluidine-2-sulphonic acid in caustic soda solution below 10° (*cf. B.P.*, 452, 139). A thick cream-coloured paste (II) is formed, which on drying gives a cream-coloured powder (III). On extraction with ethyl acetate (I) is obtained in pure form. Compound (I) has been compared with the pure chemical constituents of commercial textile auxiliary agents, such as Igepon T, Igepal L, Nekal BX, Aerosol OT, Gardinol WA and Triton NE, for which determinations of wetting power in terms of the Herbig number and the time of sinking test, calcium soap dispersing power and protective colloidal action, are made. It is found that (I) exhibits higher wetting power than any of these products except Aerosol OT, which is better than (I) judged by the flotation test and gives a higher Herbig number at 0·25% concentration, although below 0·1% the two are equivalent. Compound (I), Igepon T, Igepal L and Triton NE have nearly the same calcium soap dispersing power, and the other auxiliaries range below these products. Compound (I) is also a better protective colloid (as indicated by the Congo Rubine Number) than the commercial products examined.

The crude product (III), containing nearly 73% of (I), is next compared with the commercial auxiliaries without purification of the latter. With the exception of Aerosol OT, which again had higher wetting power, and Igepal L, which is a better calcium soap dispersing agent, (III) has better all-round properties than the commercial products. The wetting agent in the paste form (II) also compares favourably with the commercial products. Technical production of (I), covered by Indian Patent 27,443 and Brit. Pat. 545,496, will shortly be undertaken.

88. Influence of phenols on phenol reagent.

N. ROY *and* U. P. BASU, Calcutta.

In estimating colorimetrically chlorocresol by phenol reagent (Ray and Basu, *Indian Jour. Med. Res.*, 1943, October issue) it has been noticed that the reducing capacity of chlorocresol is less than that of pure phenol.

The influence of different substituents in the phenol molecule is being studied and so far it has been noticed that the above reduction of the molybdate in the phenol reagent and the consequent oxidation of the phenolic molecule are solely dependent on and influenced by the nature and position of the substituents in the phenols themselves. In cases of strongly negative substituents like nitro, carbethoxy, sulphonic acid groups particularly at the *para* position, the reducing property of the phenol is considerably lowered, and as such *p*-nitrophenol, *p*-hydroxy-benzoic acid and similar other bodies cannot be estimated by the phenol reagent. The other compounds like chlorophenol, various cresols, though reducing the phenol reagent to a lesser or greater degree, can, however, be easily estimated by the above reagent after first finding out the molar equivalent with respect to phenol.

89. On the alkaloidal constituents of *Alstonia Scholaris*, R.Br. Part II.

S. SIDDAPPA, Bangalore.

Demethyl echitamine, $C_{21}H_{26}O_4N_2$, $2H_2O$, prepared by the hydrolysis of echitamine hydrochloride, $C_{22}H_{28}O_4N_2$, HCl, isolated from the bark of *Alstonia Scholaris* (*Proc. Ind. Sc. Cong.*, 1942, p. 82), on reaction with soda-lime gives a material (m.p. 75°) yellow in colour, and readily soluble in water, alcohol and benzene. Its analysis gives the formula $C_{40}H_{50}O_3N_4$ and is probably formed by the loss of a molecule of water from two molecules of decarboxylated demethyl echitamine:—

$$2C_{20}H_{26}O_2N_2 \xrightarrow{-H_2O} C_{40}H_{50}O_3N_4.$$

Reaction of demethyl echitamine with methyl iodide results in a substance, which on crystallization from water melts at 238°, and has $[\alpha]_D 25° = -53{\cdot}6°$ (C = 0·84 in water).

Demethyl echitamine does not add on any hydrogen in presence of Pt catalyst in methyl alcoholic or acetic acid solution.

With the object of obtaining some knowledge about the chemical nature of echitamine, demethyl echitamine has been subjected to oxidation with permanganate and dehydrogenation with selenium.

90. Chemical examination of the bark of *Prunus Puddum* (N.O. *Rosaceae*).

D. CHAKRAVARTI *and* R. P. GHOSH, Calcutta.

The compound, m.p. 282°, isolated from the bark of *Prunus Puddum* (N.O. *Rosaceae*) (*Proc. Ind. Sci. Cong.*, 1943, Part III, p. 28) has been found to be a flavone, 7-methoxy-4′:5-dihydroxyflavone and it has been named *Puddumetin*. It forms a diacetyl derivative (m.p. 191–93°) and a monomethyl ether (m.p. 168°), which also forms a monoacetyl derivative (m.p. 190-91°). Puddumetin, on demethylation with hydriodic acid, gives apigenin (m.p. 344–46°). On hydrolysis with alcoholic potassium hydroxide it gives *p*-hydroxy-acetophenone (m.p. 102–5°; semicarbazone, m.p. 192-93°). It has been suggested by Venkataraman that *Puddumetin* may be identical with genkwanin, isolated by Nakao and Tseng from the Chinese drug *Yuen-hua*.

91. Proximate analysis of coconut husk at various stages of retting.

N. S. VARIER, Trivandrum.

During the retting of coconut husks, complex chemical and bio-chemical changes take place. To study the chemical changes, coconut

husks at various stages of retting in the laboratory and in the field have been analysed in terms of (i) moisture, (ii) ash, (iii) fats and resins, (iv) cellulose, (v) lignin, (vi) pentosans, (vii) pectins, and the results are given.

92. Chemical investigation of the poisonous principles of the seed kernels of *Cerbera Odollam*, Gaertn.

A. NARAYANAN POTI, Travancore.

In view of the confusion in the scanty published work on the active principles of the seed kernels of *Cerbera Odollam*, a detailed investigation was undertaken. Three distinct crystalline cardiac glycosides, *cerberin*, *odollin* and *odollotoxin* have been isolated and characterized.

Cerberin and *odollin* have been hydrolyzed to the aglucones *cerberetin* and *odollogenin* and their characteristics studied.

The reactions of the three glycosides and the two aglucones are typical of the presence of the unsaturated lactone side-chain of the cardiac glycosides and aglucones.

Cerberin gives an isomeride, *iso-cerberin* (m.p. 257°) by the action of alcoholic alkali.

The sugar in *cerberin* gives an unidentified phenylhydrazone (m.p. 122°). Glucosazone has been obtained from the products of hydrolysis of *odollin*.

93. Fatty acid composition of tobacco seed oil.

C. VENKATARAO, M. NARASINGARAO *and* A. VENKATESWARULU, Guntur.

The oil from Virginia tobacco seeds has been examined and the fatty acid composition determined. Mixed fatty acids consist of myristic 1·8%, palmitic 7·8%, stearic 5·6%, oleic 30·2% and linoleic 54·6%. The oil contains 1·9% non-saponifiable matter which is mainly sito-sterol (m.p. 141°).

The determination of glyceride structure of the oil by the method of bromination and separation of bromo-glycerides from various solvents is in progress.

94. Oil from the seeds of *Bombax Malabaricum*.

C. VENKATARAO, M. NARASINGARAO *and* A. VENKATESWARULU, Guntur.

The oil from the seeds of *Bombax Malabaricum* contains 94·8% insoluble mixed fatty acids composed of 57% of solid acids and 43% of liquid acids. The composition of the fatty acids is found to be 1·2% myristic acid, 23·6% palmitic acid, 2·8% arachidic acid, 64·9% oleic acid, and 7·5% linoleic acid. The seed cake is found to contain 34·4% crude protein.

95. The fixed oil from the seeds of *Phyllanthus Emblica*.

R. RAMACHANDRA IYER *and* K. R. KRISHNA IYER, Trivandrum.

The seeds of *Phyllanthus Emblica* on extraction with petrol yields 13·8% of its weight of a fixed oil. Physical and chemical constants of the oil have been determined.

96. The chemical examination of the active principles of *Phyllanthus Niruri.*

R. RAMACHANDRA IYER, Trivandrum.

From the alcoholic extract of the plant *Phyllanthus Niruri* a crystalline needle-shaped glucoside, m.p. 152°, has been obtained. It gives a benzoyl derivative melting at 184° and an acetyl derivative melting at 161°. On hydrolysis with 2% sulphuric acid it gives glucose, which has been identified through its osazone. Further work is in progress.

97. Chemical examination of the tubers of *Holostemma Annulare.*

P. V. NAIR *and* K. S. MADHAVAN PILLAI, Trivandrum.

The dried tubers of *Holostemma Annulare* furnished indications of the occurrence in them of an unknown sugar which manifested the characteristics of a hexose. The sugar itself has not been isolated in a pure condition, but a methyl derivative (m.p. 156-7°) as well as the hydrazone (m.p. 185°) and osazone (m.p. 132°) have been prepared. The tubers contain over 24% of sugar, 35% of starch and 12% fibre. The ether extract of the tuber furnishes a colourless crystalline substance (m.p. 96°), the chemical nature of which has not yet been elucidated. *Holostemma Annulare* belongs to the natural order Ascelepiadaceae and grows wild in many parts of South India and Ceylon. A decoction or paste of the tuber is administered by Ayurvedic physicians in the treatment of diabetes, ophthalmia, and as a lactative for nursing mothers.

98. Chemical examination of the seeds of *Moringa pterygosperma.* Part I.

K. N. SHAMASASTRY *and* H. SUBBA JOIS, Bangalore.

The seeds of *Moringa pterygosperma* contain a high percentage of fatty oil which is used to relieve the pain of gout and rheumatism.

The seeds have been divided into two parts, the outer husk and the inner pulp, and each part is extracted successively with different solvents. The total extracts obtained are 14·4% and 47·39% respectively from the husk and inner pulp.

Various constants of the yellow fatty oil from the petroleum ether extract have been determined.

99. Chemical examination of the seeds of *Luffa Amara* (Roxb.).

A. SEETHARAMIAH *and* H. SUBBA JOIS, Bangalore.

A systematic investigation of the constituents of the seeds of *Luffa Amara* has been undertaken. The seeds have been crushed and extracted successively with different solvents. The total extract amounts to 24·56%.

The petroleum ether extract is found to consist of pinkish brown viscous oil. When this is set aside for two to three days a solid separates. This consists of a colourless crystalline material (m.p. 56–58°) and constitutes 1·2% of the seeds. This is acidic and soluble in sodium bicarbonate. Various constants of the pinkish brown fatty oil have been determined. Further work is in progress.

100. Chemical examination of *Adiantum caudatum* (Linn).

A. SEETHARAMIAH *and* H. SUBBA JOIS, Bangalore.

Adiantum caudatum (Sanskrit—Mayura Sikha) is a fern belonging to the family of Filices The fern is used in Ayurvedic medicine in skin

diseases and diabetes. The present investigation forms a systematic study of the various substances present in the fern. A sample of the well-dried and finely powdered plant material is successively extracted in a Soxhlet with different solvents.

The substance which volatilizes in steams possesses a fine aroma and amounts to 0·12%. The plant answers the tests for the presence of alkaloids but the amount does not exceed 0·04%. The extracts of petroleum ether and ethyl acetate both yield a fine white crystalline compound (m.p. 235–237°). The alcoholic extract answers the tests for the presence of reducing sugars and gives osazone.

101. Fossil resin from the lignite beds at Warkalay.

N. S. VARIER, Trivandrum.

The fossil resin (sp. gr., 0·96 to 0·98; moisture, 4·3%; ash, 1·3%) is not completely soluble in benzene or turpentine or 90% alcohol. Destructive distillation yields an oil (85%) and combustible gases. The constants of the oil and the fractions obtained by distilling the oil (i) at ordinary pressure, (ii) under reduced pressure, are given.

102. Note on the sterol separation from cane-wax.

C. VENKATARAO *and* M. NARASINGARAO, Guntur.

Cane-wax from press-cake is separated into higher melting wax (m.p. 82°) and lower melting wax (m.p. 53-54°), hard cane-wax being best used in boot polish and for raising the m.p. of solid lubricants, and soft wax being suitable for leather dressing. The soft wax is found to contain all the sterol content of the wax. The non-saponifiables are subjected to chromatographic analysis and the sterols are partially concentrated in the top sections of the adsorption column.

103. Chemical examination of the medicinal herb, *Aerva Lanata*.

P. V. NAIR *and* K. S. MADHAVAN PILLAI, Trivandrum.

Aerva Lanata, a small branching plant, belonging to the natural order *Amaranthaceae*, grows wild in various parts of India and is put to a variety of uses in Ayurvedic pharmacy, the most noteworthy among which is the administration of a decoction of its roots in the treatment of internal hemorrhage, gonorrhoea and kidney disorders. A porridge, made from a mixture of rice and roots of the plant, is believed to confer very beneficial results in enriching blood during gestation. The dried plant gives as much as 16·1% ash from its shoots and 10·5% ash from its roots. The ash contains 50% of calcium (as CaO) and about 24% of iron (as Fe_2O_3). The pharmacological action of the drug is probably due to the presence of such high percentages of calcium and iron in an assimilative form.

104. Coconut pith.

P. GEORGE VARGHESE, Trivandrum.

Coconut pith has been analyzed in terms of the following:—

1. Moisture 11·10%, (2) Ash 5·8%, (3) Fat and resin 5·54%, (4) Cellulose 38·81%, (5) Lignin 50·50%, (6) Pentosans 16·53%, (7) Pectins 0·82%.

The high percentage of ash like 30% reported by some authorities on coconut might be due to ashing unwashed pith which always contains sand and salt from saline water. In none of the samples examined, the

ash is greater than 6·5% and ranges between 5–6·5%. The ash of the pith has been analyzed.

(1) Water soluble 21·5%, (2) Insoluble 41·5%, (3) Alumina 0·17%, (4) Iron 2·88%, (5) Calcium 2·72%, (6) Potassium 0·54%, (7) sulphate 4·43%, (8) Chloride 9·15%, (9) Carbonate 12·49%.

Unlike the ash of the husk, pith ash is poor in potassium. Hence the manurial value of pith is very limited.

105. Catalytic synthesis of higher hydrocarbons from carbon monoxide and hydrogen.

S. L. SASTRY, Bangalore.

The catalytic synthesis of liquid hydrocarbons from carbon monoxide and hydrogen has been studied using various catalysts containing cobalt, at atmospheric and medium pressures. A Co-Cu-ThO_2-Kieselguhr catalyst has been prepared which, with the synthetic gas ($CO:H_2$, 1 : 2), yields nearly 124 g. of higher hydrocarbons/c.m. of the original gas mixture at 195° and at normal pressure.

A Co-Cu-Cr_2O_3-ThO_2-Ce_2O_3-Kieselguhr catalyst has also been prepared which, working with a gas mixture containing CO and H_2 in the ratio of 1 : 1 synthesizes as much as 165 g. of higher hydrocarbons/c.m. at an optimum pressure of 5 atmospheres and optimum temperature of 205°-206° and may, therefore, be applicable for the large-scale production of liquid hydrocarbons from purified commercial water-gas.

106. Arsonation of the condensation products of *p*-acetaminobenzenesulphonyl chloride with aminophenols and anisidines.

P. P. KRISHNAN *and* P. C. GUHA, Bangalore.

p-Acetaminobenzenesulphonyl chloride has been condensed with *o*-, *m*- and *p*-aminophenols and *o*-, *m*-, and *p*-anisidines. The amino compounds, obtained by the hydrolysis of the acetamino compounds, have been arsonated according to Bart's method and the resulting hydroxy- or methoxy-phenyl amino-sulphophenyl-arsonic acids have been described.

107. On the utilization of Indian turpentine oil. Catalytic dehydrogenation of carenes in liquid and vapour phases.

P. C. GUHA, A. N. ROY *and* MADHUSUDAN PAUL, Bangalore.

Indian turpentine oil contains about 50–60% of Δ^3-, Δ^4-carenes. Dehydrogenation of carenes to *p*-cymene in the presence of various catalysts has been studied both in liquid and in vapour phases with a view to exploring the possibility of utilizing *p*-cymene (from carene obtained from Indian turpentine oil) as starting material for the manufacture of synthetic thymol, carvacrol, menthol, etc. Dehydrogenation reactions in liquid phase have been carried out between 130° and 165° with sulphur in the presence of various reaction promoters like activated charcoal, zinc chloride, and some vulcanizing agents like diphenyl urea; optimum yield of *p*-cymene obtained is 35–40%. Catalytic dehydrogenation of carenes in vapour phase at elevated temperatures gives encouraging results. The reactions are carried out in a flow system with Cr_2O_3-Al_2O_3 and Ni-Cu as catalysts. With Ni-Cu as catalyst yield of 55–60% *p*-cymene is obtained at 450–500°. In the presence of Al_2O_3-Cr_2O_3 catalyst at 450°, dehydrogenation of carenes proceeds smoothly, yield 60%. Above 500° decomposition of carenes begins with deposition of carbon. The Al_2O_3-Cr_2O_3 catalyst can be used repeatedly without deterioration and can be reactivated.

108. Chemical investigation of the leaves of *Nyctanthes arbortristis*, Linn. (N.O. *Oleaceae*).

C. R. MEHTA, Baroda.

On account of its high medicinal reputation, the chemical examination of the leaves has been carried out. The hot air dried leaves have been successively extracted with various solvents.

A careful search of the extracts with various solvents has showed the presence of a substance of an alkaloidal nature in the alcohol extract only, giving characteristic precipitates with specific reagents for alkaloids. A large-scale extraction of the leaves to obtain the alkaloid in a better yield and in a purer form is being carried out. The extracts are being examined to isolate other principles, if any.

109. Chemical examination of the seeds of *Abutilon indicum*, G. Don. (N.O. *Malvaceae*).

C. R. MEHTA, Baroda.

The bark, the root, leaves and seeds of *A. indicum* are all used in medicine. The investigation of the seeds which have been extracted successively with petroleum ether, ether, chloroform, alcohol and other solvents, have, therefore, been undertaken. A pale yellow fatty oil (about 10%) has been obtained from the petroleum ether and ether extracts. The constants of the oil have been determined. The chemical examination of the oil and other extracts is in progress.

110. A new constituent of East Indian sandalwood oil: Isolation of β-santalic acid.

S. BHATTACHARYYA, Bangalore.

East Indian sandalwood oil is generally known to contain about 14 chemical substances comprising of alcohols, hydrocarbons, acids, aldehydes, ketones, etc. A new monobasic acidic substance of the molecular formula $C_{15}H_{22}O_2$ has recently been isolated. The substance has b.p. 202°/9 mm.; n_D^{20} 1·5136. It is a weak acid and cannot be properly titrated by alkali. The silver salt is insoluble and comparatively stable towards light. The methyl ester, which has been prepared from the silver salt and the alkyl iodide, has b.p. 157°/9 mm.; n_D^{20} 1·4989. Oxidation with percamphoric acid reveals that the substance contains two double bonds and consequently a bicyclic ring structure. A probable structural formula of the substance has also been suggested.

111. Reaction between substituted succinic anhydrides and aromatic hydrocarbons in presence of anhydrous aluminium chloride.

M. A. SABOOR, Dacca.

The reaction between asymmetric dimethylsuccinic anhydride and benzene has been studied and it has been found that the product undergoes interchange between a ketonic acid and a hydroxy-lactone. The use of trimethylsuccinic anhydride tends to the stabilization of the hydroxy-structure, the ketonic form being completely absent.

When tetramethylsuccinic anhydride is employed, a substance is obtained which is not formed by the simple addition of the benzene molecule to the anhydride but a molecule of carbon monoxide is eliminated to give a degradation product, the possible structures of which have been discussed.

112. Analysis of carbarsone (*p*-carbamido-phenylarsonic acid) synthesized in India.

R. C. GUHA, Calcutta.

Carbarsone either in powder or tablet form, synthesized by five different Indian companies, is analyzed by the U.S.P. Xi method. Altogether 20 samples of carbarsone powder and 100 samples of tablets or capsules have been assayed for arsenic percentage in the case of powders and for quantity of carbarsone per tablet in the case of those put up in tablet form. Comparative estimations have also been made on carbarsone capsules and carbarsone tablets manufactured by a reputed foreign firm, Eli Lilly & Co.

The arsenic content in the powders examined varies from 27·10–28·46%, the standard being 28·1–28·8% arsenic. In the tablet, the carbarsone contents varies from 0·144 to 0·257 g. per tablet claiming to contain 0·25 g. of carbarsone per tablet. The tablets of the 'Lily' brand are found to contain 0·221 to 0·227 g. per tablet against a claim of 0·25 g./tablet. Those powders, which give a lower arsenic percentage than the standard, usually give a m.p. not conforming to the standard m.p. of 169–171°.

Excepting a few samples, most of the Indian products are found to be of standard quality from the chemical point of view.

Biochemistry

113. Influence of adenine and oxalic acid on the oxidation of vitamin C.

P. SESHAGIRI RAO, Bangalore.

In continuation of the previous work on the inhibiting action of purine compounds, nucleic acids, etc. on the oxidation of vitamin C (*Proc. Ind. Sci. Cong.*, 1942, III, p. 168) a comparative study has been made of the influence of adenine and oxalic acid at various *p*H values on the oxidation of vitamin C under different conditions: (*a*) autoxidation, (*b*) oxidation by copper, and (*c*) oxidation by ascorbic acid oxidase. Adenine is found to annul both the auto and Cu catalyzed oxidations of the vitamin in the acid as well as in the alkaline region. On the other hand, oxalic acid exerted more protein against the auto and Cu oxidations of the vitamin at acid *p*H, the optimum being *p*H 5·0, and its inhibitory property is gradually destroyed with increasing *p*H, the inhibition at and above *p*H 7·2 being very little. The enzymic oxidation of the vitamin is not annulled by either of these two compounds. The cause of the destruction of the inhibitory action with increasing *p*H in the case of oxalic acid and the mechanism of the inhibition exerted by adenine and oxalic acid against the auto and Cu catalyzed oxidations of vitamin C are being investigated.

114. Milk clotting enzyme in *Ficus Carica*, L., latex.

D. N. HAKIM *and* V. JAGANNATHAN, Bangalore.

The milk clotting enzyme of the latex of the domestic fig tree (*Ficus Carica*, L.) has been concentrated and a product fifteen times more active than the original latex has been obtained. The latex itself has an activity of 400 per gram, i.e. 1 gm. of latex being enough to clot 40,000 c.c. of milk in 10 minutes at 40°. The product obtained after purification has an activity of 6,000 units per gram sufficient to coagulate roughly 600,000 times its own weight of milk. The enzyme can be precipitated with ammonium sulphate and alcohol but not satisfactorily with sodium chloride. About 50% activity can be recovered in alcohol precipitation while ammonium sulphate gives 80–85% recovery. In fractional precipitation

most of the activity is obtained at 40–45% saturation with ammonium sulphate and 50–55% with alcohol.

The study of the properties of the concentrated product shows that for activity the optimum temperature is 75° and optimum *p*H 5·4. Dialysis against running water results in loss of activity. It is activated by calcium salts; addition of 1% of calcium lactate to the milk doubles the activity of the enzyme. Further investigation is in progress.

115. Shark-liver oils.

P. V. NAIR *and* T. A. RAMAKRISHNAN, Trivandrum.

The physical and chemical characteristics for the liver oils of five different species of sharks, indigenous to Travancore waters, are determined and set forth in tabular form.

116. Protective action of chemical inhibitors on shark-liver oil.

P. V. NAIR *and* T. A. RAMAKRISHNAN, Trivandrum.

The inhibiting action of various inorganic and organic chemicals on the development of rancidity in Travancore shark-liver oil, as measured by Wheeler's titrimetric peroxide determination, has been investigated. Sulfanilamide, allantoin, lactic acid, iodine, arsenious oxide, sodium hypophosphite, and lithium carbonate have been used as antioxidants. Sulfanilamide has been found to possess the greatest inhibiting action.

117. Protective action of inhibitol fractions from oil meals on shark-liver oil.

P. V. NAIR *and* T. A. RAMAKRISHNAN, Trivandrum.

The influence of inhibitol fractions from the oil meal extracts of the seeds of *Mucuna pruriens*, Australian chestnut, and Osbeckia on the course of autoxidation of Travancore shark-liver oil has been studied by Wheeler's titrimetric estimation of peroxide values. Positive results are obtained in the case of the Mucuna inhibitol fraction, while the other two produce practically no effects.

118. Thiamine content of foodstuffs.

M. N. RUDRA, Patna.

A simple method, using Prebluda and McCollum's reagent, has been worked out for determining the thiamine content of biological materials including urine. Among the foodstuffs examined *Lens esculenta* has been found to be the richest and *Lathyrus sativa* the poorest in thiamine content.

119. Groundnut meal as human food.

U. P. BASU *and* S. K. GANGULY, Calcutta.

The cake that is left behind after extraction of the oil from groundnut is being used in feeding farm animals. It has now been found that from the same cake a flour rich in easily digestible protein concentrate for human consumption may be easily produced. The meal that has been obtained possesses a fragrant smell, is palatable to taste and consists of protein 42·6%, carbohydrate 32·3% and fat 6·65%. It is also rich in mineral salts and vitamins. The amino acids present in the protein are arginine, histidine, cystine and lysine. It is expected that the meal would offer a good protective food to the starch-consuming agricultural population of India and would indirectly give a fillip to the groundnut oil industry of the country.

120. Biogenesis of lichen acids.

T. R. SESHADRI, Madras.

A scheme of evolution of the depsides and depsidones is presented. Orsellinic acid structure is the fundamental skeleton and it is derived from carbohydrates. Depside formation, nuclear carbonation, oxidation and ether formation are further stages. The occurrence of the large number of lichen acids is explained.

121. Pharmacological study of some synthetic lactones and compounds related to santonin.

(MISS) K. D. PARANJAPE, N. L. PHALNIKAR, B. V. BHIDE *and* K. S. NARGUND, Poona.

Some synthetic lactones and analogues of santonin have been prepared and tested for their anthelmintic action by their effect on earthworms. The method used is the immersion method of Sollmann (*J. Pharm. Exp. Therap.*, 1919, **12**, 129). The following conclusions have been arrived at regarding the pharmacological action and chemical constitution:—

(*a*) *l*-Santonin and racemic santonin are equally reactive.

(*b*) Analogues of santonin, without methyl groups are less active than santonin.

(*c*) The 2-keto $\Delta^{3:4}$-, $\Delta^{1:9}$-hexahydronaphthalene and its alkyl analogues are as active as santonin and in this class of compounds the effect of methyl substituents is marked. It appears, therefore, that in santonin the dienone structure is important in giving it the anthelmintic action.

(*d*) Lactone derived from tetrahydronaphthols, similar in structure to desmotropo-santonin, are active while the corresponding tetrahydronaphthols are inactive. Desmotropo-santonin, however, is inactive probably because it is sparingly soluble in water. This indicates that the action of santonin is predominantly due to its ketonic group.

(*e*) βp-Methoxy (hydroxy)-γ-phenyl-γ-alkyl-γ-butyro lactones are highly active as well as toxic when the alkyl group contains less than 5 carbon-atoms.

122. Dehydrogenase activity and inorganic substrates.

K. MADHUSUDANAN PANDALAI, Trivandrum.

Dehydrogenase activity has so far been tested only with respect to organic substrates, the biological oxidations of ammonia, nitrite, hydrogen sulphide, etc. where inorganic energy releases serve in the utilization of carbon dioxide for carbon assimilation, having been left out. Working with six different systems possessing established hydrogen activating capacity and purely inorganic substrates containing ammonium salts it has been shown that these systems cannot activate hydrogen in inorganic combination. It is inferred that the mechanism of oxidation by autotrophic agencies in inorganic substrates and that by heterotrophic systems in organic substrates are fundamentally different.

123. Chemical examination of Indian rhubarb (*Rheum Emodi*, Wall.).

G. K. RAY *and* R. C. GUHA, Calcutta.

Several varieties of Indian rhubarb, stated to have been obtained from Kashmir, Kangra Valley, Nepal, Sikkim and Assam, have been examined according to the methods and standards laid down in the British

and the United States Pharmacopoeias. Total ash, acid-insoluble ash, 45% alcohol extractive matter, 49% alcohol extractive matter, presence of emodin and chrysophanic acid and ultra-violet fluorescence analysis for limit of rhapontic rhubarb are determined and compared with figures obtained for 'Official' rhubarb, *Rheum palmatum*. Excepting one variety of Indian rhubarb, all other varieties pass the B.P. limits for total ash, acid-insoluble ash and alcohol (45%) extractive matter. All the samples pass the tests laid down in the U.S.P. It is concluded that Indian rhubarb can be easily used as a substitute for pharmacopoeial rhubarb, though in physical characters and in the colour of its powder, it differs from the 'accepted' variety of rhubarb.

Industrial Chemistry

124. Preparation of photographic sensitizers.

M. Q. Doja *and* Muktdeo Pandey, Patna.

The preparation of six sensitizers suitable for the manufacture of ortho-chromatic, panchromatic, and infra-red photographic plates, from materials available in the country, has been described. The sensitization spectra of all these compounds have been determined and discussed. The dyeing properties of two of them and the fluorescence of all have also been examined and recorded.

125. Synthesis of cyanine dyes.

M. Q. Doja *and* Muktdeo Pandey, Patna.

Three new dyestuffs have been obtained by the condensation of *p*-diethylaminobenzaldehyde with the ethiodides of lepidine, *p*-toluquinaldine and 6-ethoxy-quinaldine. One of these compounds, the *p*-toluquinaldine condensation product, has been found to be a powerful sensitizer which can be commercially utilized. Unlike other cyanine dyes, these substances dye silk and wool in fast colours. The fluorescence and other characteristics of these dyes have also been examined and recorded.

126. New methods for the preparation of alkali dichromates from Indian minerals, using (i) sodium sulphate, (ii) calcium carbonate.

S. S. Joshi *and* Jadu Nandan Sahay, Benares.

The importance of dichromates is illustrated by its huge import figure. It is also important as a war material. A new method in this line was developed by Joshi and co-workers in the electrolysis of a fused mixture of potassium nitrate and chrome iron ore, both of which are abundantly available in this country (*Proc. Ind. Sci. Cong.*, 1942, *Chem. Sec.*, Abstract 208).

Attempts at substituting sodium sulphate for potassium nitrate met with difficulty due to the high fusion temperature of the sulphate. The present work reports data on the use of the alkali sulphate to produce dichromate *thermochemically* by the use of bisulphate at an intermediate stage. The interaction of the bisulphate with the chromite ore when carried out under conditions, which have been worked out, produces dichromate in good yields.

Another method which does not appear to have been employed in this line uses calcium carbonate. Limestone and the chromite ore, on heating under certain regulated conditions of temperature and duration, and in the presence of certain catalysts, yield calcium chromate. The fused mass is lixiviated in the presence of sodium sulphate, and under certain

conditions of concentration and temperature yields sodium chromate; on acidification the yield is about 40% dichromate.

127. Electrochemical preparation of magnesium persulphate and hydrogen peroxide by the electrolysis of $MgSO_4$, $7H_2O$, in sulphuric acid.

D. N. SOLANKI *and* P. S. SASTRY, Benares.

The electrolysis of only H_2SO_4 (60%) at low temperature gives persulphuric acid which on hydrolysis under suitable conditions gives hydrogen peroxide. The current efficiency (C.E.) in the above case falls rapidly with duration. But by using $MgSO_4$, $7H_2O$ in sulphuric acid, the C.E. can be kept up high for a long duration. A mixture of 45% of $MgSO_4$, $7H_2O$ and sulphuric acid gives very good yields. The optimum conditions have been worked out.

The C.E. gradually increases with increasing concentration from 20–45% of $MgSO_4$, $7H_2O$ and remains a constant for 45–50%. Results indicate that C.E. gradually increases with increasing anodic C.D. of 18–61 amp./dm^2, reaches a maximum at 61 amp./dm^2 and falls when the C.D. is higher. Temperature is also an important factor as the C.E. is constant at 5°–15°, and falls gradually at temperatures higher than 20°. The C.E. decreases gradually as the duration is increased. The influence of addition reagents is very remarkable as the C.E. is raised from 67–74% with 1% of K_2F_2. By using a diaphragm of earthenware clay the C.E. is enhanced from 67–82% and by a combined use of diaphragm and 1% K_2F_2, the C.E. can be raised to 90%.

128. The electrolytic preparation of sodium persulphate from Glauber's salt, $Na_2SO_4 . 10H_2O$, for the production of H_2O_2.

D. N. SOLANKI *and* I. S. K. KAMATH, Benares.

The electrolysis of sulphuric acid at low temperatures gives persulphuric acid which can be hydrolyzed under suitable conditions to hydrogen peroxide. The persulphuric acid obtained is unstable and the current efficiency (C.E.) also decreases with time. With a mixture of Na_2SO_4 and H_2SO_4, however, the comparatively stabler sodium persulphate is obtained and the C.E. is far higher also. The optimum conditions for the production of sodium persulphate have been determined.

With alkaline or neutral aqueous solutions of Na_2SO_4, the C.E. is practically zero; it increases as the acidity is increased and reaches a maximum when the concentration of H_2SO_4 is 60%. For *anodic current density* (C.D.) between 50 to 110 amp./dm^2 the C.E. is maximum and is constant. Due to the precipitability of the Na_2SO_4 it is difficult to work at temps. below 10°. For temps. ranging between 10° and 15° the C.E. is constant within 1%, but falls rapidly with higher temps. HF, $KClO_4$, $NiSO_4 . 7H_2O$, etc. improve the current yield; 1 gm. of HF raising the C.E. by 15%. The solution containing 1% of HF on electrolysis using an unglazed diaphragm gives a C.E. of 92·74%. Factors like *current concentration, inter-electrode distance* and *cathodic C.D.* have but little influence on the C.E.

129. Electro-synthesis of potassium permanganate at reduced pressure.

K. VENKATESWARA RAO, Benares.

A new method was developed by S. S. Joshi and co-workers for the electro-synthesis of potassium permanganate from Indian raw materials,

viz. potassium nitrate and manganese dioxide. It was thought desirable to study the influence of reduced pressure on this reaction.

Potassium nitrate and manganese dioxide were taken in the proportion 5 : 2 on the basis of previous experiments, and fused in a hard glass test tube coated with asbestos. The tube was constantly evacuated by means of a Cenco pump and the fused mixture electrolyzed. The potassium manganate formed was estimated as Mn_3O_4 and the current efficiency calculated therefrom. Results obtained indicate that there is no appreciable change in current efficiency with the reduction in pressure, as compared with the results of Joshi and co-workers in these laboratories.

130. The utilization of heavy oil residue for cracking in the manufacture of oil gas.

K. L. MOUDGILL and A. N. POTI, Trivandrum.

In the distillation of high speed diesel oil, after the recovery of 90% distillate, about 8% of a tarry heavy oil residue was accumulating as a waste product. This was evaluated for gas making according to the method of Griffiths and the results tested out by performance in the Mansfield oil gas installation. The laboratory evaluation gave a factor of 79% efficiency on yield of gas (kerosene oil = 100) after making allowance for the carbon content of the raw material. The performance in actual manufacture gave a 72% efficiency which is in fair agreement with the theoretical.

The composition of the gas has been determined and compared with that of the standard (from kerosene). The gas shows mainly a higher methane content and a lower content of illuminants but the total calorific value calculated from the composition is only very slightly less than the standard. This cheaper raw material has completely replaced the more costly kerosene for the manufacture of gas, in the Travancore University Gas Plant and has given satisfactory service during the past two and a half years.

131. Indigenous rubber yielding plants of Travancore. Part I. *Alstonia Scholaris.*

M. SREEDHARAN PILLAI and K.S. MADHAVAN PILLAI, Trivandrum.

The possibilities of utilizing indigenous plant resources for obtaining latices suitable as substitutes for Hevea Rubber Latex are being examined and the present paper deals with the data obtained for the latex of the tree *Alstonia Scholaris* (N.O.: *Apocyanaceae*) which grows extensively in Travancore. The flow of latex varies from 5 c.c. to 3 oz. at a single tapping. The chemical examination shows that the latex contains only about 4·5% of rubber which quantity is too low for commercial exploitation. The following physical and chemical characteristics have been noted: Colour, milky white; odour, nil; specific gravity (30°), 1·0315; acid value, nil; coagulable matter, 28·3%; steam volatile matter, nil; total solids, 32·2%; composition of the latex has been determined.

132. Studies in industrial fermentations—lactic acid.

K. K. IYER and M. SREENIVASAYA, Bangalore.

1. *L. bulgaricus* has been found to be the organism more suitable for the fermentative production of lactic acid than *L. acidophilus* and a few other lactic bacilli so far studied.

2. The saccharification of the starchy component in Jowar is best achieved through the agency of a diastatic enzyme rather than by an

acid. The hydrolysate resulting from the enzymatic hydrolysis offers a far more favourable medium not only from the point of view of the growth of the organism but also from the point of view of the percentage of sugar conversion.

3. Conversions ranging from 70 to 80% of the sugar in the hydrolysates from Jowar and potato have been obtained. A 30% yield on the weight of the sugar is obtained from molasses.

133. Adulteration in Travancore lemon grass oil.

N. S. Varier, Trivandrum.

The possible adulterants available in the lemon grass growing areas are methylated spirit, kerosene oil and fixed oils. The effect of these adulterants on the physical constants of the oil is discussed. Details of the examination of a large number of samples collected from distilleries, shopkeepers and other dealers of the oil are given. It is found that adulteration is very rare and only methylated spirit is used for the purpose.

134. The retting of coconut husks.

P. George Varghese *and* N. S. Varier, Trivandrum.

Retting of coconut husks has been studied with four distinct objects in mind, namely: (1) to study the chemical changes, (2) to shorten the duration of retting, (3) to improve the quality of fibre, (4) to find some use for the by-products. It has been found that during retting chemical changes of a very complex nature take place. The duration of retting which ordinarily is about 6 to 10 months has been reduced to 1½ months by soaking the crushed husks. Chemical treatment has little effect on the duration of retting. A number of factors has been found to affect the quality of the fibre. The colour of the fibre is improved by 0·5% oxalic acid treatment. Husk pith has been tried to make corks and pads with some success.

135. Sulphur in the retting grounds of coconut husks.

N. S. Varier *and* K. M. Pandalai, Trivandrum.

During the retting of coconut husks, especially in 'pit-soaking', considerable quantities of sulphur are formed besides hydrogen sulphide. Since the husks contain very little sulphur and the Kayal waters, in which retting takes place, contain sulphates, the sulphur is likely to be formed by reduction of the sulphates. Sulphate-reducing bacteria are shown to be present in the retting medium. This sulphur can easily be converted into sodium thiosulphate.

136. Investigations on the contraction of oil-well cements.

A. Reid *and* N. C. Sen-Gupta, Calcutta.

In cementing strings of pipe (or casing) in place in an oil-well, cement slurries of pumpable fluidity have to be used. The hydrostatic pressure imposed on the cement slurry during the placement of the cement may be considerable and a high percentage of the excess water in the slurry may filter into porous formations with which the cement comes in contact. This filtration of excess water results in an appreciable reduction in the volume of set cement from a given volume of slurry.

If the cement slurry is allowed to stand for some time before it comes in contact with the porous formation, the contraction is much less, but since the viscosity of the cement slurry rises as the cement 'ages' this remedy

cannot be applied in practice. By an impermeable mud lining the amount of water filtering into the formation from the cement is much reduced. It is, however, not desirable to have a mud layer between the formation and the set cement.

There is another form of contraction of the cement not associated with loss of water to the formation; this may be as high as 6%. Chemical treatment of the cement will partly obviate this.

137. Polymerization of vinyl acetate.

S. K. K. Jatkar *and* S. Krishnamurthy, Bangalore.

Polymerization of the vinyl acetate has been undertaken for the Mysore Archaeological Department to preserve the 52 feet idol of Lord Gautamaheswara in Sravana Belagola, Hassan District. The commercial sample has to be distilled to remove the inhibitor-copper salt. Hydrogen peroxide and benzoyl peroxide are used as catalysts. Polymerization has been carried at atmospheric pressure on a water-bath. The polymer is soluble in all common solvents. Experiments have been conducted to study the water-absorbing property of the films. Physical measurements have been made to follow the rate of polymerization.

138. Anti-corrosive varnish.

S. K. K. Jatkar *and* S. Krishnamurthy, Bangalore.

The oil extracted from the shell of the cashew nut contains anacardic acid and cardol. This oil is abundantly available in the Malabar districts. It has been much used in the United States of America in the paint and varnish industry. Experiments have been conducted to utilize the oil in conjunction with drying oils to give varnishes of the baking type. The oil is condensed with formalin and the resulting resin is dissolved in dehydrated castor oil, prepared in these laboratories. Baked films of this varnish show outstanding resistance to chemical attack and are very adherent. Further commercial possibilities of the varnish are under investigation.

139. Modifications of shellac.

H. K. Sen, Ranchi.

(*a*) *A sealing composition for containers.*

A suitable composition for sealing containers has been developed.

One hundred parts of shellac are mixed with 50 to 100 parts of hydrolyzed lac, 10 parts of castor oil and 8 parts of sodium acetate and the whole fused at 120°–130° for two hours. The resultant product, which at ordinary temperatures is tolerably hard and elastic, is melted before using for sealing purposes.

(*b*) *Shellac adhesive tapes.*

(i) One hundred parts of hydrolyzed lac and 24 parts of linseed oil or castor oil fatty acids are heated at 150°–160° for two hours, at the end of which 20 parts of glycerine are added and the heating continued at 140° for three hours more to reduce the acid value from 140 to 80. The viscous mass is then cooled to 50° and weighed. The mass is then taken up with twice its weight of denatured alcohol. The resultant solution is then mixed with some finely ground pitch or any alcohol-soluble dye and applied to the tape either by dipping or brushing. The prepared tape is then allowed to be air-dried before reeling.

(ii) A second composition is prepared by heating 100 parts of hydrolyzed lac with 10 parts of glycerine and 10 parts of phthalic anhydride

and heated at 130°–140° for two hours. The resultant viscous mass is cooled and taken up with spirit as described in the previous composition.

(*c*) *Shellac-linseed oil fatty acid-lime compositions for plastic moulding.*

A simple and satisfactory method of preparing shellac moulding powders is to soften lac with a dilute solution of liquor ammonia and after the addition of linseed oil fatty acid, slate lime, stearic acid and wood-flour to render the materials homogeneous by passing the mixture between steam-heated steel rollers.

The material comes off in the form of homogeneous sheets from the rollers and is then powdered to 60 mesh and dried at 90°–95° for three hours. Suitable moulding conditions for such a composition are 125°–130° and a pressure of 1 ton per sq. inch for 1½ to 2½ minutes according to the size of the articles.

(*d*) *Interaction of shellac and shellac acids with organic acids and alcohols.*

A translucent flexible composition from shellac has been prepared by condensing suitable proportions of shellac with organic acids like adipic, maleic, suberic and such other acids in the presence of polyhydric alcohols like glycol, glycerine, etc. by heating at 170°–180° for about an hour. The melt is poured into porous moulds and baked at 120° for twenty-four hours. Hard elastic articles can be produced, which can be sawed or machined.

140. Polymerization of shellac.

H. K. Sen, Ranchi.

Pure resin of shellac is known to polymerize to an insoluble, infusible stage under the influence of various agencies such as heat, HCl vapour, age, etc. It has now been possible to isolate an intermediate stage of polymerization of pure resin, provisionally called semipolymer, which is soluble and fusible but has higher softening point and melting point and lower fluidity. It has been proved by molecular weight determination by Rast's method that the semipolymer is a dimer formed by the elimination of water from two hydroxyl groups between two different molecules of the pure resin. The deterioration of properties, such as flow, life under heat, etc., of shellac on storage with only a slight increase of alcohol-insoluble is now explained as due to the gradual formation of the semipolymer.

141. A simple method of manufacturing urea.

H. K. Sen, Ranchi.

The usual process for the manufacture of urea depends upon the reaction of gaseous carbon dioxide with ammonia under pressure and heat. In the process described in this paper, a mixture of ammonium carbonate and carbamate is produced by distilling a water solution of an equimolecular mixture of sodium carbonate and ammonium sulphate at the boiling temperature of water. The volatile products, ammonium carbonate, carbamate and steam are passed through a condenser kept at 60–70° which returns practically all the steam condensed as water, the carbonate and carbamate of ammonia subliming and condensing in a specially prepared aluminium chamber. There is arrangement in the plant for the return of solutions of ammonium carbonate to the generating boiler.

The mixture of ammonium carbonate and carbamate which is collected by scraping from the sides of the aluminium chamber usually has an ammonia content of 38–41%, which is next transferred to a steel autoclave (lined with tin or lead) capable of withstanding 1½–2 tons of pressure.

The autoclave is then heated by superheated steam or direct fire to 160° and maintained at that for 2½–3 hours. After cooling down the autoclave to 95–100° the excess of unreacted ammonium carbonate is recovered in the usual way, and the residue which is a concentrated solution of urea is discharged and evaporated to yield crude solid urea. On redissolving, filtering and reconcentrating, pure urea of a melting point 130–132° is recovered. The yield of urea is 22-23% of the carbonate and carbamate mixture, whilst about 75–80% of the unreacted carbonate is recoverable.

Allowing a proper value for the sodium sulphate produced in the reaction $(NH_4)_2SO_4+Na_2CO_3 = (NH_4)_2CO_3+Na_2SO_4$, the cost of urea works out at 2½ annas per lb.

Instead of using soda ash, concentrated form of *reh* can also be used.

SECTION OF GEOLOGY AND GEOGRAPHY

President:—A. S. Kalapesi, B.A., B.Sc., D.I.C., Ph.D. (Lond.), F.G.S., F.R.G.S.

Mineralogy

1. Heavy mineral study of the Barakar sandstone, Singrimari, Garo Hills, Assam.

N. N. Chatterjee, Calcutta.

A Gondwana patch at Singrimari (89° 54′ : 25° 44′) in the district of Garo Hills, Assam, lies against the metamorphics on the east and consists of coarse grained felspathic sandstone, sandy shales and carbonaceous shales. The sedimentary beds dip towards west. The Gondwana sandstone at some places is highly pebbly or conglomeratic.

The paper gives an idea of the heavy minerals present in the coarse grained sandstone. The specimens were crushed, cleaned and subjected to bromoform treatment to collect the heavy minerals. The amount thus collected was found to be 0·6% of the rock. The heavy minerals identified under the microscope include iron oxides, zircon, garnet (both colourless and pink variety), muscovite, tourmaline, monazite, epidote, biotite, hornblende, etc. in order of abundance. One or two bits of kyanite were detected.

A critical study of the results obtained in the present case and a reference to the work done by previous authors on this subject show that the smaller amount of garnet (2·6%) and an appreciable proportion of zircon (4·5%) in the heavy residue indicate definitely a Barakar age to this Singrimari sandstone.

2. Chemical compositions of some chromite minerals occurring in Mysore chrome ores.

M. R. Anantanarayana Iyer, Bangalore.

In this paper the chemical compositions of seven samples of chromite including a strongly magnetic one are given and compared in two ways: one, by expressing the percentage compositions in terms of the molecules, $FeO.Cr_2O_3$, $MgO.Cr_2O_3$, $MgO.Al_2O_3$, $FeO.Fe_2O_3$ and $MnO.Fe_2O_3$, whose relative proportions differ in the samples and the other, by marking the samples by points in a graph devised by E. S. Simpson.

The strongly magnetic chromite is particularly interesting.

The graph is a square divided into four equal minor squares by the x and y axes. The values of the expressions

$$(1)\ \frac{(MgO-FeO)\text{ molecules}\times 100}{(MgO+FeO)\text{ molecules}} \quad\text{and}\quad (2)\ \frac{(Al_2O_3-Cr_2O_3)\text{ molecules}\times 100}{(Al_2O_3+Cr_2O_3)\text{ molecules}}$$

are used respectively to mark off the x and y axes of the samples. Points denoting all chromites will lie in the two lower minor squares. The chromites discussed in this paper fall under four sub-species, for one of

which the strongly magnetic sample seems to be the first recorded representative and it is a Fe_2O_3-rich variety. Hence the strongly magnetic chromite is seen to be doubly interesting.

Petrology

3. A brief account of the Madan Mahal granite, Jubbulpore, C.P.

N. N. CHATTERJEE, Calcutta.

In the neighbourhood of Jubbulpore town there are two exposures of granite. One known as Madan Mahal granite occurs a few miles to the south-west of the town. The other patch occurs to the north of the Jubbulpore Rly. Station and has a linear extension in a more or less east-west direction.

The present paper deals with the Madan Mahal granite which is found to be intrusive in the older talcose schists. Definite inclusions of talcose schists in the granite have been detected in the field and are supposed to be parts of country rock *in situ* as such inclusions have more or less the same foliation direction as the country rock. These inclusions have been very much impregnated with the granitic material.

Some biotite rich foreign inclusions (xenolith) are also found in the granite. The granite at places appears to be very much contaminated. The usual coarse-grained variety of granite is found to contain chiefly quartz, felspar (both orthoclase and oligoclase) with occasional perthitic intergrowth, biotite, bluish amphibole, epidote, etc.

Certain structural features of this granite such as joint system, quartz, tourmaline veins, etc. have also been described in the paper.

4. The lamprophyres and the associated rocks in the neighbourhood of Lohardaga, Ranchi district, Bihar.

H. L. CHHIBBER, Benares.

Lohardaga (23° 27′ : 84° 41′) lies on a very gently undulating lower plateau and is about 2,100 feet above the sea-level. The geology of this area comprises the following rock-types:—

11. Alluvium.
10. Laterite and lateritic soil.
9. Bauxite.
8. Kaolin and lithomarge.
7. Hybrid rocks.
6. Granite.
5. Lamprophyres.
4. Graphic granite, pegmatites, aplites and quartz veins.
3. Porphyritic granite-gneiss.
2. Diorite and microdiorite.
1. Metamorphic schists.

The oldest metamorphics include quartz- and mica-schists and quartzites and by the intrusion of igneous rocks these have been converted into various kinds of hybrid rocks. About 150 yards below the confluence of the South Koel river with the Banki *nadi*, the diorite sets in.

The granite-gneiss has a very wide extension and builds a large plateau from the Chitupallu Ghat to a few miles past Lohardaga *en route* to Gumla.

Various modifications of this granite-gneiss are encountered in the field.

Injections of graphic granite, pegmatites, aplites and quartz veins are commonly observed in this gneiss.

The lamprophyres comprise: (i) hornblende-biotite lamprophyre or biotite-vogesite, and (ii) biotite-lamprophyre or minette.

Biotite-vogesite occurs in four localities.

Biotite-lamprophyre or minette occurs near the village of Bagru. The main rock near this village is porphyritic granite-gneiss. It has been injected by pegmatites composed chiefly of quartz and felspar.

The norm of the rock contains no felspars but leucite and nepheline occur instead.

Economic Geology

5. On the occurrence of a galena deposit in Jaipur State, Rajputana.

K. L. DAS, Agartala (Tripura State).

The deposit is situated at about three miles to the east of Chauth-Ka-Barwara Railway Station on the Jaipur State Railway. The area is almost covered up with soil. The mineralized zone brought out to observation during my visit was about 300 ft. long and 50 ft. broad. The gossan is absent and probably has been washed away. The general trend of the zone is N.E.–S.W.

The country rocks belong to the Delhi series, mainly composed of phyllites and ferruginous quartzites. The dip in the quartzites is from 54°–62° towards west, the strike being N. 7° E.–S. 7° W. They are highly crushed and fissured and these fissures are filled up with quartz.

The ore is mainly galena with some amount of cerussite. It is crystalline to granular. Big crystals are very rare. Quartz and barytes are the main gangue minerals with some feldspar. Sometimes pyrites and chalco-pyrite are found embedded in the gangue quartz. Patches of malachite are very common. Quartz and barytes of the gangue are often found highly impregnated with galena.

6. On the occurrence of pottery clay and glass sand at Champamura, Tripura State, Bengal.

K. L. DAS, Agartala (Tripura State).

The deposit is situated at Paschim Champamura which is about three miles to the east of Agartala town (long. 91° 19′ 31·3″, lat. 23° 50′ 13·4″). There are motorable path and navigable hill-stream passing by the side of the deposit. The nearest railway station on the A.B. zone of the B. & A. Rly. is Akhaura which is nine miles away.

The clay occurs as a bed at the base of low hill ranges. The dip is not discernible, but it appears to be horizontal. The upper surface of the bed is very uneven, probably due to denudation after its deposition. The composition of the bed is very varying. In one place it is composed of pure clay and in another position on the same level it is of pure sand. The clay is highly plastic. Some representative unwashed samples were analyzed chemically. Two of those results are noted below:—

Clay.

SiO_2	61·03
Al_2O_3	28·70
Fe_2O_3	1·01
CaO	0·49
MgO	0·18
Loss on ignition	10·24
Total	101·65

Sand.

Loss on ignition	1·84
SiO_2	88·75
$Al_2O_3 + Fe_2O_3$	7·84
CaO	0·49
MgO	0·81
Total	99·73

General Geology

7. The origin of Talchir boulder beds in parts of Warangal district, Hyderabad (Deccan).

C. MAHADEVAN, Hyderabad (Deccan).

During the geological survey of the eastern parts of Warangal district, outliers of Talchirs were mapped and studied in some detail. The 'basal boulder beds' consist of a heterogenous assemblage of partially rounded pebbles and boulders of various sizes from half an inch to two or three feet in diameter, all of which are embedded in a fine arenaceous silty matrix. *Both undecomposed and decomposed felspars occur in the matrix.* The so-called 'striations' are seen only in such pebbles and boulders as *banded* quartzites or granite *gneiss* and are entirely absent in the other rock boulders to which banding is not inherent.

Sandstones from other geological formations in the area, such as the Pakhals or the Kamthis, contain both decomposed and undecomposed felspars in precisely the same manner as do the Talchirs. Torrential rains in areas with certain types of topography easily account for the deposition of 'boulder beds'. The paper attempts to show that these boulder beds of the Deccan owe their origin to fluviatile and not to glacial agency. It is suggested that glaciation at the commencement of the Gondwana period manifested itself in pluvial conditions nearer the tropics.

8. Thermal mineral springs in the eastern parts of Warangal district, Hyderabad (Deccan).

C. MAHADEVAN, Hyderabad (Deccan).

Two thermal springs, one in the bed of the Godavari, south of Gundala village (17° 38′ : 80° 56′) and the other near Bugga village (17° 55′ : 80° 44′), were observed during the geological survey of the eastern parts of Warangal district. The water from the springs bubbles up as small spouts intermittently and emits a strong sulphurous smell and is perceptibly acid in taste. The temperature of the water is about 60°C. in both the springs.

A careful examination of the two areas reveals clear fault zones between the Gondwana formation (Kamthis) and the earlier rocks. In the case of Gundala spring, the earlier rocks are the Archaeans and in that of Bugga, the Pakhals (Cuddapahs ?). The paper describes the geology of the two areas and discusses the probable causes of origin of these thermal mineral springs.

Geography

9. Geomorphology of Tripura State, Bengal.

K. L. DAS, Agartala (Tripura State).

The State lies between 22° 55′ and 24° 31′ north latitude, and 91° 10′ and 92° 20′ east longitude. Two types of hill ranges have been noticed, viz. tectonic and subsequent ranges. The main ranges of tectonic origin from west to east are: Baramura, Deotamura, Atharamura, Longtarai, Sakhan and Jampui. The general trends of these ranges are north to south. Their heights are increasing from west to east. The trends of the subsequent ranges are diverse in directions. They are the outcome of the erosional effect on the main country posterior to its formation.

There are two types of valleys, viz. tectonic and erosional. The rivers Khowai, Dholai, Manu, Deo and Longai are flowing towards north

following the tectonic valleys whereas Gumti, Muhuri and Fenny are flowing towards west and south-west following the erosional valleys.

There are some fresh-water lakes, i.e. Rudrasagar and Brahma Bill. They are situated by the sides of existing rivers. Marshes and bogs are mainly confined to the western sides of the State.

Amongst the perennial water-falls the Dumbura falls may be mentioned. There are beautiful rapids of different origin at the river beds.

10. Regions of Western India.

C. D. DESHPANDE, Dharwar.

Western India forms one of the major divisions of the country. Administratively, it includes the Bombay Province, Deccan and Gujarat States, Baroda, the Western India States Agency and the Portuguese possessions on the West Coast. Its orientation towards the Arabian Sea, a long coast line, administrative and economic influence of the Bombay Metropolitan Region, have forged a bond of unity over the whole region. Owing to these influences, Western India stands out as a distinct geographical region. Its regional study can be suitably undertaken on the basis of a primary division of the region into its cultural zones, viz. Karnatak, Maharashtra, Gujarat, Kathiawar and Cutch. Sub-regions are distinguished on the basis of the physiographical setting and economic development, since these, in Western India, are the major influences governing natural and cultural landscape. This paper suggests a division of Western India into its geographical regions, and considers the major aspects of the geography of each region.

11. A regional survey of the Ganges-Gogra Doab.

DATA RAM SINGH, Meerut *and* MANECK B. PITHAWALLA, Karachi.

The Ganges-Gogra Doab, the biggest section of the Upper Ganges Basin, the physiography of which was dealt with last year, forms part of the richest, most populous and most historically famous region of India.

The Doab is divided into physiographic sub-section from the points of view of surface configuration, soil fertility, water-supply, economic resources, industrial possibilities, population problems, lines of communication, etc.

The main divisions are:

Section.	*Major Sub-Section.*	*Minor Sub-Section.*
Ganges-Gogra Doab	(*a*) Upper Ganges-Gogra	(i) The Middle Ramganga Valley.
		(ii) The Middle Sarda Valley.
		(iii) The Sot Valley.
	(*b*) Middle Ganges-Gogra	(i) The Middle Ganges-Gumti Doab.
		(ii) The Middle Gumti-Gogra Doab.
	(*c*) Lower Ganges-Gogra	(i) The Baran Valley.
		(ii) The Lower Tons Valley.

In making the above divisions, the geographical peculiarities of each is brought about and its general geology, surface topography, soils, Kalar lands, water resources, drainage, etc. are considered. The Ganges-Gogra Doab is comparable with the Ganges-Jamna Doab in several geographical aspects and economic conditions. In the present paper, an attempt is also made to indicate the geographical distribution of the various resources of the region with their influence on the life of the people of the Doab, which is the chief point of all such surveys.

12. A plan for the development of the Thar desert in Sind: a study in applied geography.

G. S. RAISINGHANI *and* MANECK B. PITHAWALLA, Karachi.

The present paper deals with the Thar desert section which presents geographical features and characteristics of a physical unit.

The paper in the first part reviews the geographical features and economic conditions relating to the soils, minerals, natural vegetation, animal life, agriculture, industries, settlements, communications and transport. The second part deals with the proposals and the plan for the development of the Thar. The boundaries have also been revised.

A plan has been formulated for reconstruction as follows:—

(*A*) *Improved water-supply:* by collecting rain water in the large-sized reservoirs and employing small-sized wind mills for lift irrigation; and by reconstructing cement-lined closed water tanks for the drinking, cooking and washing purposes;

(*B*) *Agricultural development:* comprising (i) soil husbandry; (ii) more economic and useful crops; (iii) more and better fodder; (iv) control of crop pests and diseases; (v) mixed farming; (vi) utilization of culturable waste lands;

(*C*) *Industrial progress:* including (i) cattle breeding and dairying; (ii) embroidery; (iii) weaving; (iv) leather works; (v) tanning and dyeing of hides; (vi) bone factory; (vii) exploitation of industrial and medicinal plants;

(*D*) *Social and economic uplift* of the Thari people; and

(*E*) *Communications and transport.*

The paper is accompanied by a list of the natural vegetation of the Thar and a number of maps of Sind and the Thar drawn for the first time.

13. Intensive farming in the Punjab.

KAZI SAIDUDDIN AHMAD, Aligarh.

In two previous papers the author discussed that water-supply was the principal factor in the 'distribution of population' and 'economic holding'. In this paper he has carried his argument further and shown that water-supply is also one of the principal factors in intensive farming in the Punjab.

Although the holdings are characteristically small, intensive farming is practised to a very limited extent. Low standard of living, primitive methods of cultivation, great Summer heat, passive attitude of the farmer, diet, slow urbanization, want of capital for the improvement of land, all stand in the way of intensive farming. Educational system has not been much adapted to rural needs. Even the economic pressure has not forced the hands of the cultivator into intensive farming to any appreciable extent, as the increase of population and rise in the cost of living have been amply offset by increase in the cropped area, following improvements and extensions in irrigation.

But though slow, there is a distinct trend towards commercialization of agriculture in the Punjab, specially in the canal colonies. Wheat, American cotton, sugarcane and oilseeds form the principal cash crops.

14. Sind's contribution towards national planning in India based on her geographical features.

G. S. RAISINGHANI *and* MANECK B. PITHAWALLA, Karachi.

The paper discusses India's unique position in the post-war reconstruction in view of her vast economic resources and potentialities and further indicates Sind's contribution towards Indian national planning.

The need and scope of Indian national planning have been pointed out properly, by surveying the peculiar geographical distribution of crops, minerals, raw materials and industries with the help of maps, specially drawn. The method of attaining provincial self-sufficiency based upon the geographical features of each region has been presented. The exports of certain raw materials from India and the import of necessary finished goods and consequent industrial backwardness, poverty, unemployment and low standard of life in India have been commented upon with facts and figures.

The main part of the paper deals with the geographical distribution of crops, minerals, raw materials and industries in Sind and the prospects of exports of some raw materials and of imports of finished goods. This shows Sind's surplus produce which it can offer in exchange of those in which it is naturally deficient.

A plan for the economic development and industrial progress in Sind, based upon her geographical features, is well under way.

15. Population trends of Parsi settlements on the West Coast of India.

BEHERAM S. H. J. RUSTOMJI *and* MANECK B. PITHAWALLA, Karachi.

The Parsis form a microscopic minority in the country. In proportion to the total population of India their percentage comes to ·03 only. Though they are scattered all over India, they show extreme concentration on the West Coast. Nine-tenths of the country's Parsi population is concentrated in the Bombay Presidency, and over half of that in the city of Bombay itself. The Parsis are rarely found except in colonies of their own, in Bombay, Surat, Navsari, Broach, Karachi, Poona, etc.

This paper deals with the trends of the Parsi population on the West Coast. It shows how it is distributed, what has been the trend of its growth, how the population has been divided into urban and rural areas, British and Native States, and what the tendency of its migration from one place to another is. It also refers to the age distribution, civil condition and vital statistics of the community. The main trend of the community, as revealed by the census figures, 'distinctly suggests a danger ahead'.

The partial decay of settlements as in Broach and Surat and the rapid growth of colonies like Karachi and Poona are marked as of special interest.

The paper is accompanied by maps, diagrams and graphs.

16. Irrigation in India.

GEORGE KURIYAN, Madras.

The paper gives a geographic account of irrigation with a detailed survey of the various modes of irrigation as they are practised at the present day. Methods for the expansion of irrigation and for improving the distribution and lifting of water are suggested. The factor of power development from irrigation reservoirs is also discussed.

17. Hydro-electric development in South India.

G. KURIYAN *and* SRI V. P. KANNAN NAIR, Madras.

The paper attempts to describe and discuss the place of water power in South India, what it has done and could do for the industrial regeneration of a region lacking in any other form of power. The recent developments of power have all been followed up by a tremendous phase of very rapid

industrialization. Nothing is so vital to India as the development of her latent power resources, which will be the precursor of an industrial age in India. Japan with poorer resources both in power and raw materials has been able to develop her industries very much more fully. India has a much higher potential which however is allowed to lie dormant. It is time that it is fully tapped.

18. The marine fisheries of the Sachin State.

S. T. MOSES, Baroda.

Introduction—The fishing caste—Machis—Nets, boats and capital invested—Other occupations—Health, sanitation, education, etc.—Fishing and methods—Fishing grounds—Stake nets—Destruction of small fish—Drift nets—Drag nets—Cast nets—The barrier net—Mudskipper fishing—Seasons of fish—Chief kinds of fish, prices, etc.—Other kinds of fish—Fish trade—Sales—Markets—Payments—Monsoon difficulties—Suggestions for fishery development.

SECTION OF BOTANY

President:—T. S. SABNIS, D.Sc., F.A.Sc., I.A.S.

Algae

1. An ecologico-physiological study of the algae of rice fields of the Punjab and Kashmir.

SHAMS-UL-ISLAM KHAN *and* P. L. ANAND, Lahore.

Algae from some rice fields in the Punjab and Kashmir have been studied. Attempts have been made to prepare pure, unialgal and bacteria-free cultures, of some of the algae. A modification of H. C. Bold's method has been suggested for the isolation of algae. In all 350 species belonging to various groups have been distinguished, which include three new species, six new varieties and five new forms. A number of new records for rice fields have been added.

2. Succession of algae during the stages of complete reclamation of barren Kallar soil in the Punjab.

SHAMS-UL-ISLAM KHAN *and* P. L. ANAND, Lahore.

In the initial stages of succession Myxophyceae are the pioneer forms especially those that are provided with thick, firm, gelatinous or mucilaginous covers or sheaths. As the soil is reclaimed, the hardy forms of Myxophyceae disappear and the delicate ones take their place. Chlorophyceae in the true sense appear but quite late in succession. When the soil approaches the end of reclamation the Chlorophyceae become very dominant.

The *p*H value of the medium appears to be the chief controlling factor in succession.

3. Algal vegetation of the estuary of the Gomti river.

SHAMS-UL-ISLAM KHAN *and* P. L. ANAND, Lahore.

The algal vegetation along the Gomti Ghat is not so luxuriant as on the rocks in its vicinity but there is clear zonation present. The following belts are recognized:—

(1) *Lyngbya confervoides—Calothrix pulvinata—belt.*
(2) *Chroococcus minutus—Calothrix contrenei—belt.*
(3) *Enteromorpha—Ulva—belt.*

In all 67 species, 13 belonging to Chlorophyceae, 1 to Phaeophyceae, 5 to Rhodophyceae and 48 to Myxophyceae, have been recorded. It includes one new species, two new varieties and one new form.

4. Study of algae from Kashmir.

SHAMS-UL-ISLAM KHAN *and* P. L. ANAND, Lahore.

The paper deals with a study of the algae collected by Mr. Pinfold, from ponds, pools and nullahs near Srinagar, Gulmarg and Ningal. In all 178 species have been described including four new species, twelve new varieties and four new forms.

Fungi

5. Experimental studies on the parasitism of citrus fruits by *Penicillium digitatum saccardo.*

H. K. Baruah, Calcutta.

Penicillium digitatum sacc. infects oranges through wounds and causes a soft-rot. Infection is possible only if the wound extends through the epidermis and the layers of subepidermal cells which are not attacked and softened by the enzymes secreted by the fungus. Oranges with one or two layers of resistant cells only are attacked through shallow wounds and may be termed susceptible to attack. Oranges with three to four layers of resistant cells are not attacked through shallow wounds and may be termed resistant to attack. Invisible wounds sufficiently deep to allow infection to occur can be detected by immersing oranges in an enzyme extract coloured with methylene blue.

Penicillium digitatum grows readily in culture. The rates of spread of colonies are greatest on agar media to which orange juice or extracts of orange rind are added. The weights of mycelium formed in liquid media are greatest in those enriched with orange juice or extracts of orange rind.

The production by *Penicillium digitatum* of enzymes which attack pectin and plant tissues is also favoured by orange extracts. The maceration of orange itssue is due to the removàl of pectic material, the hemicelluloses and cellulose not being attacked.

6. Fungus flora of the soil and reduction of carbohydrates by them.

Som Dutta *and* H. Chaudhuri, Lahore.

An ecological survey of the fungal flora of Kallar soils and some under reclamation has been made. There is a gradual increase in flora—both in species and number—as we proceed from unreclaimed Kallar soil towards reclaimed one.

Besides above, the fungal flora of paddy fields and of sewage farms have been studied. Soil from sewage farm has been found to be richest in flora.

Paddy soil was poorer in flora during the time when fields were flooded with water. But after the crops had been harvested there was a general increase.

Aspergilli were most abundant both in species and number. Penicilli fall next to them. Mucorales were altogether absent in the Kallar soil due to the absence of organic matter, but they were much abundant in sewage farm soil on account of its being richer in organic matter.

During winter the number of fungi in the soil was greater than in the summer months.

Soils rich in organic matter and neutral or slightly acidic in reaction are richer in fungal flora than those which are poorer in organic matter and alkaline in reaction.

Regarding reduction of carbohydrates, Mucorales though altogether inactive towards cellulose were found to be most active reducers of starch.

7. Hereditary (seed-borne) symbiosis in *Casuarina equisetifolia* Forst.

S. R. Bose, Calcutta.

In continuation of my work on symbiotic fungus in *Casuarina equisetifolia* reported last year in *Proc.* 30*th Indian Science Congress*, Calcutta, 1943, the fungus has been provisionally identified as *Phoma casuarinae* Tarsi. The fungus in the pericarp-wing of the fruits and in seed-coats infects the radicles of seedlings and comes uot on the outside

of the radicle, five-septed hyphae can be seen along with the dense rows of root-hairs when seeds are germinated on moist filter-paper in petri-dishes. Micro-Kjeldahl estimation is going on to find out if it can fix free nitrogen from the atmosphere in pure cultures in nitrogen-free (sucrose and mineral salts) medium.

Out of *C. equisetifolia* a cutting was prepared in two months. Roots of this cutting showed the characteristic hyphae both on the outside and also in their sections. The fungal hyphae have been found throughout the body of the plant, though not in aggressive form, viz. in roots (normal and coralloid in some cases), stems, branches and green branchlets, fruit-cones, capsules and seed-coats; only the endosperm and embryo are free from fungal infection. Thus, every *Casuarina equisetifolia* plant is found to be a dual organism, harbouring a fungus in its seeds. The symbiotic relation, therefore, becomes hereditary.

Sporadic formation of ectotropic mycorrhiza has been experimentally produced in roots of a number of seedlings. In the course of 3 to 4 months roots of such seedlings bore bunches of coralloid roots containing copious rod-shaped bacteria and prominent zooglea-threads. Examination of fruits of seven other species of *Casuarina* from Australia shows the invariable presence of coil of septed hyphae in their pericarp-wings.

According to Melin (1930) mycorrhiza may be regarded as nutrient-absorbing organs (especially nitrogen-assimilating organs) for the higher symbionts. He holds that they do not assimilate free atmospheric nitrogen. Views of several workers, viz. Narasinham (1918), Rao (1923), Chaudhuri (1931), and Aldrich-Blake (1932) as regards assimilation of free atmospheric nitrogen by bacteria in coralloid roots of *Casuarina equisetifolia* have been given.

8. Pathological histology of necrotic mango fruits.

S. N. DAS GUPTA *and* S. N. ASTHANA, Lucknow.

Detailed study of the pathological histology of necrotic mango fruits has been carried out by cutting microtome and hand sections of such fruits at different stages of the development of the disease. Other technique, the details of which have been given in the paper, had also been employed. The interesting results obtained are incorporated in the paper.

9. Further investigations on the incidence of black-tip disease in mango fruits.

S. N. ASTHANA, Lucknow.

While studying the effect of SO_2 on mango fruits it was thought desirable to see if the gas penetrates through the stalk. These were, therefore, enclosed in small gas chambers specially designed for the purpose. Effect of SO_2 on such stalks, both statically and dynamically, was studied by filling these gas chambers with the required quantity of the gas while the fruits were still on the trees. The experiments were repeated in the laboratory at different temperatures on the plucked fruits. The technique of the experiment and the results are given in the paper. Other experiments to induce the disease in healthy fruits and to check it in diseased fruits as also the anatomy of the treated stalks were also done.

10. Some new or noteworthy fungi.

M. J. THIRUMALACHAR, Bangalore.

Two new species of *Puccinia*, *P. Volutarellae* Thirumalachar, *P. Bellurensis* Thirumalachar, are proposed for the accommodation of rusts occurring on *Volutarella divaricata* Benth. and *Evolvulus alsinoides* L.

The telial stages of *Aecidium Blepharidis* having been found out and *Puccinia Boerhaaviaefoliae* is proposed as a new species.

11. Studies in the Ustilaginales. II. On the mode of infection of the Bajra plant (*Pennisetum typhoides* Stapf.) by the smut *Tolyposporium Penicillariae* Bref.

R. S. Bhatt, Lucknow.

An exhaustive study has been made of the various possible modes of infection (seedling, shoot, floral and localized) by *Tolyposporium Penicillariae* Bref. It has been found that the infection takes place through the flower. The stage of maturity at which successful infection is possible and also the methods by which it can be brought about have been worked out in detail. The paper also includes the observations on the course taken by the infecting hypha, source of infection, the extent of damage in the early and the late sowings, and the increase in the intensity of the disease during successive cultivations.

12. Studies in the Ustilaginales. III. The cytology and the mode of sporeball formation in *Tolyposporium Penicillariae* Bref.—a smut of Bajra.

S. N. Das Gupta *and* R. S. Bhatt, Lucknow.

The paper deals with the behaviour of the nucleus of the mycelium of *Tolyposporium Penicillariae* Bref. during the different phases of the sporeball formation, starting from the young mycelium to the ripe spore. Various stages during sporeball formation which begin with the gelatinization of the walls of hyphae, their differentiation into sporogenous ones, the changes involved during interlacing and intertwining and the structures met with up to maturity have been closely followed.

13. Studies in the Ustilaginales. IV. The cytology of germination of the spores of *Tolyposporium Penicillariae* Bref.—a smut of Bajra.

R. S. Bhatt, Lucknow.

The paper deals with the nuclear changes involved during the germination of a uninucleate ripe spore by promycelium or by hypha and also the nuclear changes during sporidial conjugation and their subsequent germination.

14. Further observations on the incidence of black-tip disease in mango fruit.

G. S. Verma, Lucknow.

The paper deals with certain experiments carried out for the last few years on the incidence of necrosis, viz.:—

(*a*) effect of profuse watering of trees;
(*b*) utilization of various devices to prevent kiln fumes reaching the fruits;
(*c*) inversion of fruits while growing on trees, etc. along with other observations on the occurrence of the disease.

15. Mundkurella, a new genus of smut.

M. J. Thirumalachar, Bangalore.

A new genus of smut *Mundkurella* has been established to accommodate a smut on *Heptapleurum Venulosum* Seem. The sori are in

fruits, stem and leaves; heterosporous, consisting of two-celled deep brown spores and large one-celled hyaline spores, germination as in Ustilaginaceae.

16. Tip-pulp of the mango fruit.

G. S. VERMA, Lucknow.

Symptoms of the disease are described. Attempts to isolate fungal or bacterial organism have failed. Experiments to reproduce the disease by inoculation of diseased tissue to the healthy fruits have yielded negative results.

17. Occurrence of phalloids in Lucknow.

H. P. CHOWDHURY *and* G. S. VERMA, Lucknow.

Authors have collected a number of phalloids from the neighbourhood of Lucknow. The collection includes several genera—Lysurus, Anthurus, Simblum, etc.—which have not been recorded from the United Provinces. The details of structure along with illustrations are given in the paper.

Bryophyta

18. A systematic study of the mosses of the N.W. Himalayas and the Punjab plains.

KHURSHID AHMAD *and* R. S. CHOPRA, Lahore.

Since very little work has been done on the mosses of the North-Western Himalayas and the Punjab plains, the present study is an attempt to work out systematically the mosses of this area. In the present work 79 species belonging to 34 genera and 12 families have been described. The species described in this paper may be grouped under three heads, namely:—

Group I.

Mosses that have recently been described as new by Dixon—(7 species).

Group II.

Mosses that have been named as new by Dixon but have not been published so far—(5 species).

Group III.

Old established species *67* in number.

All the sketches and the description of the mosses in the II and III groups have been drawn from the material in the herbarium of the Punjab University.

19. Liverworts of Lucknow and its neighbourhood.

S. K. PANDÉ *and* S. AHMAD, Lucknow.

Collections of liverworts from Lucknow and its vicinity prior to the year 1935 include:—

(1) *Riccia Frostii* Aust. (= *R. sanguinea* Kash.); (2) *R. crystallina* L. (= *R. robusta* Kash.); (3) *R. discolor* L. et L. (= *R. himalayensis* St.); (4) *R. dictyospora* Howe; (5) *R. melanospora* Kash.; (6) *R. gangetica* Ahmad; (7) *Cyathodium tuberosum* Kash.; and (8) *Notothylas indica* Kash. Since 1935 the authors have frequently noticed: (9) *Fimbriaria angusta* St. and (10) *Plagiochasma articulatum* Kash.

(Residency Garden, Lucknow); (11) *Riccia cruciata* Kash.; (12) *R. plana* Tay. (*R. mangalorica* Ahmad is probably a synonym of this plant); (13) *R. Curtisii* Jameson (on the banks of a Jhil near Mohanlalgunj); and (14) *Anthoceros crispulus* (Mont.) Duin (by the side of a stream near Bachhrawan).

R. plana, R. Curtisii and *Anthoceros crispulus* are recorded here for the first time from India. Possibly these are growing somewhere at the base of the Kumaon-Himalayas and have been brought down to the plains by the Sarda canal.

20. *Riccia discolor* L. et L.: its allies and synonyms.

S. K. Pandé *and* S. Ahmad, Lucknow.

Riccia discolor L. et L., as at present known (Stephani, *Sp. Hep.*, I, p. 19), is based on sterile material (*Nepal*, Wallich and *Dehra Dun*, Duthie).

The authors, who have examined most of the Indian species of *Riccia*, including the original fertile specimen of *R. discolor* (Duthie, *Dehra Dun*, 1882) conclude that:—

(1) *R. discolor* L. et L., *R. crispatula* Mitt. and *R. himalayensis* St. are identical. *R. discolor* being the oldest of these should be retained as an authentic species and the other two reduced to its synonyms.

(2) The monoecious *Riccia* with echinate spores included by Kashyap in *R. himalayensis* St. is identical with *Riccia dictyospora* Howe.

(3) *R. gangetica* Ahmad is a genuine species, differing from *R. discolor* in sexuality, spore character and thallus and *R. dictyospora* in spore character and sexuality.

Pteridophyta

21. Preliminary report on the origin of shoot-borne roots on adult internodes of *Marsilea quadrifolia* L.

Girija Prasanna Majumdar, Calcutta.

Occurrence of adventive roots on adult internodes is a normal feature in *Marsilea quadrifolia.* They are borne at regular intervals on the underside of the creeping rhizome, their number increasing with the length of an internode and as many as five such roots have been counted on an internode five inches long. The origin of these roots can be traced up to a little behind the growing apex and the nodes.

The stem has a solenostele which is amphiphloic. The lateral root causes a gap in the stele. which is soon repaired. But the gap in the xylem cylinder remains open for a long time. The place of origin of the root primordium is fixed and is between the pair of protoxylem groups on the lower side of the stem. Thus all the lateral roots on an internode appear in a single row parallel to its long axis.

Gymnosperms

22. Embryology of *Cupressus funebris* (Endlicher).

(Miss) Mona Sirkar *and* P. N. Mehra, Lahore.

Ovules are initiated in the beginning of August. In one and a half years they form the seeds. In early winter no change takes place in the tissue of the ovule.

The sporogenous tissue is fairly massive and megaspore mother cells from 1–4 appear at any time in the month of March. The pollen grain is shed by the end of February in the one-cell stage.

The usual diad and a somewhat linear tetrad is formed by the middle and end of March.

As many as 1,063 free nuclei are counted in the embryo sac before wall formation begins. The archegonia are developed forming a complex of 14–17 archegonia which is surrounded by a well-differentiated jacket, in the middle of May. The pollen tube reaches the archegonial complex with its content of a large body cell, two small sterile nuclei (the stalk and body nuclei). The neck of the archegonia is tiered unlike the other members of the Cupressineae investigated. The body cell gives rise to only two identical and hemispherical male gametes. This result differing in this respect from the work of Juel and Doak in two other species of cupresses. An abnormal case of fusion of egg nucleus with ventral nucleus was also observed.

The fertilized egg sinks to the bottom of the archegonia before division. The usual tiers of pro-embryo are formed. The embryo systems were dissected by Bucholz method in November and were found to have suspensors and secondary suspensors.

23. Seedling anatomy of some species of the genus Ephedra.

A. N. Chaddha *and* P. N. Mehra, Lahore.

In the present investigation seedling anatomy of 8 species of the genus (6 Asiatic and 2 non-Asiatic) has been undertaken. The results confirm the investigations of Hill and De Fraine on the seedling anatomy of some other species of the genus in general. It is pointed out that the tract of the transfusion tissue joining the end of the plumular strands with the cotyledonary traces is not of a special nature as pointed out by Hill and De Fraine, but the region represents the real cotyledonary node in which the plumular strand has undergone sudden bifurcation to join the cotyledonary traces, associated with the appearance of transfusion tissue elements and represents the same general plan as in an ordinary node of the stem in the genus.

24. Anatomy of shoot in some Asiatic species of the genus Ephedra.

A. N. Chaddha *and* P. N. Mehra, Lahore.

Anatomy of the primary vascular system of four species of the genus has been investigated. In *E. foliata* branches with two, three and four leaves at the node have been observed and anatomically studied. Variation in number of vascular bundles even in the same branch in different internodes is a common feature of all the four species. In a few cases in *E. foliata* branches bearing two and three leaves in successive internodes have been noticed and the alteration in the general plan of the vascular system investigated.

Angiosperms. (i) Morphology

25. The embryo-sac and embryo of *Satyrium nepalense* Don.

B. G. L. Swamy, Bangalore.

The embryo-sac develops according to the Normal Type, though 6-nucleate sacs are of occasional occurrence. The haploid chromosome number is 41. The development of the suspensor is very variable, exhibiting all stages in the reduction of the suspensor organ and finally completely eliminating it from some embryos. When embryological

evidence is taken into consideration it is manifest that *Satyrium nepalense* Don. may be looked upon as a form holding an intermediate position between the sub-tribe Habenarieae and the tribe Cypripedieae.

26. A contribution to the structure of the pollen grains in the Gramineae (tribe *Paniceae*).

M. Sayeedud-Din, M. Abdus Salam *and* M. R. Suxena, Hyderabad (Deccan).

The structure of the pollen grains in 24 members of the tribe *Paniceae* has been studied in detail. They are spheroidal in shape, ranging in size from $21 \cdot 3\mu$ to $39 \cdot 94\mu$ in diameter. As in the pollen grains of the rest of the grasses, those of the *Paniceae* possess a characteristic single germ-pore, consisting of a small aperture surrounded by a thickened rim of the exine and crossed by a delicate transparent membrane, bearing a rather conspicuous thickening—the operculum at the centre. The diameter of the aperture ranges from $4 \cdot 26\mu$ to $9 \cdot 94\mu$. The shape of the pore is almost always circular. The diameter of the operculum ranges from $1 \cdot 4\mu$ to $4 \cdot 26\mu$. On the whole the pollen grains of the grasses are much more similar than dissimilar, and do not prove useful in the generic or specific identification.

27. On the occurrence of polyembryony in *Sonerila* sp.

K. Subramanyan, Bangalore.

Embryological studies carried out by the writer on a species of *Sonerila* (*S. elegans* ?) has revealed an interesting type of development of multiple embryos. From the basal suspensor cells six longitudinal groups of cells are differentiated. Two of these, which are laterally disposed, develop further into small embryos up to three-celled stage. The only other case of polyembryony so far recorded in the family Melastomaceae is in *Osbeckia hissipidissima* by the writer where it is from the nucellar cells.

28. Cases of antipodal polyembryony in *Alangium Lamarckii* Show.

D. M. Gopinath, Bangalore.

Development of multiple embryos from antipodals is a rare feature among Angiosperms. Antipodal cells developing into embryos have been doubtfully referred to in *Alnus* and *Allium*. The antipodals in *Alangium Lamarckii*, which are normally nucleate, develop in some cases into 3-4-celled pro-embryonal stage. Further development is arrested, probably due to want of nutrition.

29. A contribution to the embryology of the genus *Cassia*.

J. V. Pantulu, Vizianagram.

The development of the ovule and embryo-sac has been studied in *Cassia occidentalis* Linn., *C. obtusifolia* Linn., *C. glauca* Lamk., *C. glauca* Lamk. var. *suffruticosa* Koenig., *C. marginata* Roxb. and *C. siamea* Lamk. The ovules in all species are anatropous and bitegmic. The integument initials appear only after the primary archesporial cell has cut off the primary wall cell. The micropyle is somewhat zigzag and is formed largely by the outer integument. Further, in the region of the micropyle the outer integument for a short distance is separated from the inner by a small air-space. The nucellus is quite massive. The formation just before fertilization of an epidermal cap at the micropylar end of the nucellus with a small beak projecting into the micropyle is characteristic. The epidermis of the funicle and the adjacent part of the outer integument

on the outer side remains meristematic for a long time and close to the hilum grows out into a short hump-like structure, which persists throughout the life of the ovule.

The primary archesporium in all species is hypodermal and a primary wall cell is always formed. The earlier records about the occurrence of sub-hypodermal archesporium in some species of *Cassia* appear to be all doubtful. The megaspore-mother cell gives rise to a linear or T-shaped tetrad of megaspores, of which the chalazal develops into an 8-nucleate embryo-sac according to the normal type. In one instance in *C. glauca* var. *suffruticosa* an isobilateral tetrad of megaspores has been observed. The synergidae are prominently hooked and show the filiform apparatus. The egg is pyriform and slightly larger than the synergidae. The antipodals are definite cells and persist till the time of fertilization. The two polar nuclei meet near the egg apparatus. They fuse only just before fertilization.

30. Some observations on pollen development in *Myristica fragrans*.

A. C. JOSHI, Benares.

The central stalked anther-bearing column in the male flowers appears to be a prolongation of the floral axis rather than a structure formed by the union of the filaments. The tapetum is of the secretory type. The tapetal cells remain uni-nucleate. The pollen-mother cells in an anther-lobe are arranged in a single row. The pollen tetrads are isobilateral. The generative cell is cut off towards the inner side of the pollen grains. The mature pollen grains are 2-celled and possess a single germinal furrow. The exine is reticulate and minutely tuberculate. The investigation supports the close relationship between Myristicaceae and Anonaceae.

31. A preliminary note on the embryology of *Casuarina equisetifolia* Forst.

B. G. L. SWAMY, Bangalore.

During microsporogenesis the wall layers and the tapetum are formed by the sporogenous cells. Ovules have two integuments and the archesporium consists of two to three cells and as many as 20 embryo-sacs attain maturity and are capable of being fertilized. The pollen grain germination on the filiform stigma and the pollen tube traverses through the tissues of the ovary and comes to the chalazal region of the ovule; here it sends out branches and the particular branch which contains the sperm nuclei enters the nucellus between the antipodal elongations of the embryo-sacs and on reaching the micropylar tip of a particular embryo-sac, pierces the embryo-sac between the egg apparatus and the embryo-sac membranes and discharges its contents. Double fertilization is accomplished.

Endosperm is at first nuclear but later become cellular.

Stages in the development of the embryos are normal Abnormalities like the occurrence of double nucelli, fertilization of more than one embryo-sac in the same ovule, entry of two or three pollen tubes into the same ovule and various kinds of polyembryony are reported.

32. A contribution to the embryology of *Thymelaea arvensis* Lamk., with remarks on the affinities of the Thymelaeaceae.

J. VENKATESWARLU, Guntur.

The wall of the anther at first consists of the epidermis, endothecium, a middle layer and the tapetum. The epidermis is ruptured in the mature

anthers and the layer between the endothecium and the tapetum gets crushed. The pollen grains at the shedding stage are 3-nucleate, but in a few cases multi-nucleate pollen grains have also been observed. The sperms are elongated. Starch is present in the pollen grains.

The solitary ovule is anatropous and bitegmic. The micropyle is formed by the inner integument. The nucellus is well developed, possesses an epidermal cap and a strand of elongated cells in the chalazal part. The primary archesporial cell is hypodermal and cuts off a primary wall cell. The megaspore-mother cell gives rise to a linear tetrad of megaspores, of which the chalazal one gives rise to an 8-nucleate embryo-sac according to the normal type. The antipodals increase in number and persist, though in a degenerate state, even after fertilization. Fertilization is porogamous. An obturator is developed from the base of the style. This descends down into the micropyle and helps to lead the pollen tube towards the embryo-sac. The pollen tube empties its contents in one of the synergids. Double fertilization and triple fusion occur. The endosperm is developed according to the nuclear type. In later stages, it becomes cellular on the periphery, but remains free nuclear in the central part. It is completely consumed by the embryo in the mature seed.

The embryological study supports Hutchinson's inclusion of the Thymelaeaceae and Nyctaginaceae in one order Thymelaeales.

33. On the lenticels and stomata in mango fruits.

S. N. ASTHANA, Lucknow.

The origin and formation of lenticels which develop independently of the stomata have been traced in mango fruits. All such lenticels are first formed in the ovary. One or more of the cells becomes thick-walled, the middle lamella splits and cells get detached from the tissue and form a cavity. Such lenticels enlarge in size by further thickening and dissolution of other cells as the fruit grows in size.

The development of stomata which are formed from an epidermal cell as also their distribution have been studied. All the stomata are formed when the fruits are as small as ·15 c.c. in volume. These spread apart as the fruits enlarge thereby decreasing the number of stomata per unit area.

34. Development of the embryo-sac in the Convolvulaceae.

V. S. RAO, Bombay.

Development of the embryo-sac has been studied in six species of the Convolvulaceae belonging to three genera, namely, *Jacquemontia violacea*, *Ipomea pulchella*, *I. Horsfalliae*, *I. obscura*, *I. sepiaria* and *Operculina Turpethum*. Two or three primary archesporial cells are occasionally present in *Jacquemontia*. Otherwise there is always only one hypodermal archesporial cell, which differentiates before the origin of the integument. Parietal tissue is formed in all the species, the archesporial cell cutting off a primary wall cell in every case. The development of the embryo-sac corresponds to the normal type. The antipodals are short-lived. The fusion of the polar nuclei is long delayed.

35. A contribution to the floral organogeny, structure and development of the micro and megaspores with their gametophytes and embryology of *Aristolochia bracteata* Retz.

B. N. MULAY *and* G. D. BHARNANI, Karachi.

1. The geographical distribution and ecology and economics of *Aristolochia bracteata* Retz. and the family Aristolochiaceae have been dealt with.

2. A study of germination reveals that *Aristolochia bracteata* Retz. illustrates simultaneous germination with an average germination of 31%.
3. Development of pollen grains has been recorded as normal.
4. The pollination mechanism has been thoroughly investigated. In case the insects fail to visit the flower, self-pollination is secured by growing of the pollen tubes up to the stigmas of the same flower.
5. The mature embryo-sac shows a normal egg-apparatus, three small antipodals, which persist till fertilization, and two polar nuclei which usually lie in the upper half of the embryo-sac, and ultimately may or may not fuse with each other.
6. One male nucleus fertilizes the egg, the other fuses with either one polar nucleus or the resultant of both polar nuclei. Fertilization is porogamous.
7. In embryogeny a short proembryo of three to five cells is formed in the beginning. The terminal cell of this proembryo develops into the embryo proper, while the other cells form a short but slightly massive suspensor.
8. A portion of the nucellus is left in the mature seed unabsorbed and persists as perisperm. The endosperm formed is extensive and copious.
9. The aril arises from the spongy development of the raphe and almost covers the seed on one side.
10. The embryo is minute.
11. Further work on other members of Aristolochiaceae is in progress.

Angiosperms. (ii) Anatomy

36. Anatomical study of the mangroves of the Koringa forest, Cocanada. I. *Xylocarpus obovatus* A. Juss., syn.: *Carapa moluccensis* Bedd.

M. Sayeedud-Din, Hyderabad (Deccan) *and*
V. Venkateshwarlu, Masulipatam.

As a preliminary to the comparative study of the anatomy of the mangroves of the Koringa forest near Cocanada, the anatomy of *Xylocarpus obovatus* A. Juss. has been studied. The following characteristic features have been noted:—

(1) Single-layered hypoderm in the leaf.
(2) Lack of special subsidiary cells adjoining the stomata.
(3) Rounded secretory cells occur in the pericycle.
(4) The rachis and midrib possess a ring of vascular bundles with narrow medullary rays.
(5) In the axis, isolated stone-cells are common, and groups of bast fibres occur in the pericycle.
(6) Clustered crystals of oxalate of lime are abundant in both the leaf and the axis.

37. Anatomy of *Hibiscus sabdariffa* Linn. var. *altissima.*

B. C. Kundu, Calcutta.

Hibiscus sabdariffa Linn., particularly the variety *altissima*, has been of late regarded as an important fibre crop. It has been mentioned by early workers as a fibre-producing plant; but except the recent work of Kundu and Datta (1943) on the vascular differentiation in this plant nothing is known about the anatomy of the stem and the structure and development of the fibres which have been described in this paper.

In an internode from the base of the stem secondary xylem forms a thick zone occupying the greater part of the radial depth of the section.

The secondary phloem forms pyramidal wedges with broad bases and tapering ends (phloem tongues) containing alternating patches of soft tissues (sieve tubes, companion cells and parenchyma) and fibres.

In a phloem wedge the fibres at the extreme end of the wedge are developed from the protophloem-region; the rows of inner fibres develop later by the activity of the cambium in connection with the development of the secondary phloem. The process of development of the protophloem and secondary phloem fibres agrees in all essential details with those described by Kundu (1942) in jute. The protophloem fibres are longer and wider than the secondary phloem fibres.

38. The floral anatomy of *Ruellia tuberosa*.

V. S. Rao, Bombay.

From the vascular ring of the thalamus, ten bundles are given out for the calyx. Five of these are large and alternate with five small ones. Just after their emergence, the calyx traces, especially the larger ones, are tubular, but afterwards each divides tangentially into outer and inner branches that are radially arranged with respect to each other. It is in this paired condition that the calyx traces enter the calyx-tube, but here the inner member of each pair speedily fades out. The smaller bundles may not show this bifurcation. The vascular supply of the calyx thus consists of ten bundles. The five larger ones are the midrib bundles, while the alternating smaller bundles represent the fused laterals of adjacent sepals. After the departure of the calyx traces, the stele of the thalamus again gives out five large bundles alternating with five small bundles almost at the same level. The smaller bundles are the petal traces. The five larger strands just below the separation of the corolla-tube cut off towards the outside small flattened bundles and then disappear. The flattened bundles also enter the corolla-tube and are destined to become the staminal traces. Four of them supply the functional stamens, while the posterior one goes to the staminode. The functional stamens arise in pairs from the corolla-tube. The staminal traces in the region of the connective give off branches, which run upwards and downwards in the anther-lobes; and finally before vanishing at the apex of the connective they fork into two branches. This supports the origin of the stamen from a dichotomizing microsporophyll. The vascular supply of the gynoecium consists of four bundles, two midrib bundles of the carpels and two placento-marginal strands. Only the midrib bundles are continued into the style, which is of a hollow type.

Physiology and Ecology.

39. Vernalization of Indian crops. II. Photostage in wheat (*Triticum vulgare*) and oat (*Avena* sp.).

B. K. Kar, Calcutta.

It was previously noted that pre-sowing cold treatment (vernalization phase) with post-sowing photostage of short-day lengths were not effective in bringing a significant earliness in ear-emergence in case of Indian cereals (wheat and oat). But by substituting long days in place of short days a significant earliness sets in. This is further proved during this investigation on the strength of the following results:—

(1) Wheat varieties (I.P. 4 and I.P. 52) when exposed to long days for a period of 15 days, an earliness of 24 days was attained over the control.

(2) The exposure to long days was most effective at the stage beginning from sprouting of the seedlings to 20 days age.

(3) In oats (I.P. 1) similar treatment of long days brought about an earliness of 43 days over the control.

(4) In these cereals, the photostage begins with the sprouting of the seeds and even a limited number of long days during the proper photostage were instrumental in bringing a significant earliness.
(5) In the matter of flowering and the developmental stages leading to it, the short-day conditions of the tropics were tolerated, but availability of long days are more inducive to a rapid rhythm of the developmental phases.
(6) The nature of these cereals with reference to thermal and photophases was found to differ from the temperate or hard winter cereals.

40. The contractile roots of *Curculigo orchioides.*

RUSSELL SOLOMON, Trivandrum.

The paper embodies the results of an investigation on some aspects of root contraction. The root by contracting in length seems to exert a force on the main tuber, as a result of which the plant descends to a favourable depth in the soil. The process of contraction is scarcely automatic. It is brought about in an orderly sequence by special physiological activities. Anatomical slides show an alternate turgid and compressed layers of cells across the cortex of the root. The withdrawal of sap from the outer cortex gives the necessary clue for contraction. Contraction once started steadily increases in intensity until it finally stops with the shrivelling of the root. While the epidermis and cortical layers show structural peculiarities the central cylinder remains straight acting like an elastic rod throughout the period of contraction. The element potassium seems to play a direct rôle in effecting contraction. The contraction of root in the plant is associated with the reverse process of growth.

41. Respiration studies of the seedlings of *Avicennia officinalis* L.

F. R. BHARUCHA *and* V. S. SHIRKE, Bombay.

Though much ecological work has been recently done on the mangroves, so far very little work has been done on their physiology. Since *Avicennia officinalis* is the most dominant mangrove in the creeks of Bombay, the respiration of the seedlings of this plant was studied with a view to find out if physiologically this plant differed from ordinary land plant.

The rate of respiration of the germinating seedlings up to the eighth day stage was studied and was found to vary from hour to hour and day to day. The rate of respiration under submerged conditions was found to be slightly less than under aerial conditions, which is probably due to the limited amount of oxygen. *Pari passu*, the carbohydrate and the total nitrogen content of the seedlings for the same period, were also determined. From which it appears that in this plant also the respiratory material is hexose sugar as in other green plants.

42. Arthraxon inermis association.

F. R. BHARUCHA *and* M. S. KHAN, Bombay.

In this preliminary study, the authors have studied the flora of the Walls of Bombay and certain other mofussil places near Bombay during the monsoon. As a result of their phytosociological work, the authors have named this characteristic vegetation as an association of Arthraxon inermis. They have also studied the different facies of the same association and have estimated the calcium-carbonate content of the soil.

43. Plant indicators of water-logged areas and 'Thur' land before and after reclamation.

KULDIP SINGH *and* P. L. ANAND, Lahore.

Ten plots have been studied in various stages of water-logging, deterioration and reclamation in the Chakanwali Farm near Gujranwala.

In the water-logged areas which are completely submerged under water, *Echinochloa crusgalli* Beau., *Steria verticullata* Beau., *Polypogon monspliensis* Desf. are dominant. *Herpestris monnieria*, *Veronica anagallis*, *Rumex dentatus* and *Ranunculus scleratus* are abundant; in those that are moist, *Veronica anagallis*, *Polygonum barbatum* and *Rumex dentatus* along with *Lippia nodiflora* are common, while areas where the surface is semi-dry, *Sachharum munja* Kai (*Sachharum spontaneum* and *Equisetum debile* are dominant species.

In unreclaimed areas where the soil is in a highly deteriorated condition *Sporobolus galcifolius* and *Juncus* sp. are dominant, usually associated with *Alhagi maurorum*, *Sueda fruticosa* and *Launea nudicaulis*. The number of plants in 'Thur' soil is more as compared to 'Rukker', the type of soil which is in final stage of deterioration. *Dichanthium annulatum* is found only in 'Thur' land.

In partially reclaimed areas *Polygonum plebejum*, *Chenopodium album*, *Rumex dentatus*, *Melilotus alba* and *Erigeron lenifolius*, which are common plants of the fully reclaimed areas, are occasionally associated with *Sporobolus glaucifolius* and *Dichanthium annulatum*, the dominant ones of the unreclaimed areas.

44. Effect of temperature and vernalization on the excised roots of some crop plants.

SAT GURU DUTT *and* H. CHAUDHURI, Lahore.

Wheat var. C591, C518, 8A; cotton var. 39 Mollisonii, 43F, 289/43F; gram var. F8, S.I.F. 8, type 7; and maize var. M.S. 2 (white) and No. 3 (red) seeds were germinated under aseptic conditions and the excised roots were grown in White's solution at different temperatures ranging from 20–30°C. The daily growth rate of the above excised roots was studied and compared with growth of the excised roots of the same plants vernalized beforehand by chilling, and the results discussed.

45. Detailed investigations on the effect of sulphur dioxide and other gases on the mango fruit.

S. N. DAS GUPTA, G. S. VERMA *and* S. N. ASTHANA, Lahore.

The authors have carried out experiments on the effect of sulphur dioxide and ethylene gas both singly and in admixture by static and dynamic processes; various devices were employed to observe the effect of these gases on fruits while still on the trees and on plucked fruits in the laboratory. The usual lesions were produced. Very small doses for prolonged period by dynamic processes have also failed to produce the black-tip disease.

The detailed experimental data, mechanism of experiment and the results are discussed in the paper.

46. On photo-periodic effect on jute plants.

J. C. SEN GUPTA *and* NIRAD KUMAR SEN, Calcutta.

Two species of jute, *Corchorus capsularis* (D 154) and *C. olitorius* (chinsura green) were exposed to a shorter period of about 10 hours in daylight at two stages. In the first set (Treatment I) plants were exposed from the time of germination and in the second set (Treatment II) com-

mencing when they were 30 days old, the short-day treatment lasting for 60 days in each case, and the third set growing normally served as control.

Growth and development were followed by weekly readings of height of the stem, number of internodes, total leaves and their approximate length, dates of differentiation of flower-buds and fruits.

Both the plants responded rather remarkably to short-day treatment, by early initiation of flowers and fruits and this was associated with great modification of general vegetative characters. Plants remained much shorter, with thinner stems, became bushy with a larger number of branches, fewer internodes, leaves, etc. Changes usually observed towards the last stages of vegetative growth, like the shedding of leaves, drying of lower branches set in much earlier.

A comparative account of the dates of flowering and fruiting in the control and treated plants are recorded in the following table:—

Treatment.	Mean date of flowering in number of days.	Earliness from control.	Time of flowering in days after commencement of treatment.	Mean date of fruiting in number of days.	Earliness from control.
(*C. capsularis*)					
Treatment I	32·6	81·5	27·6	47·6	87·0
Treatment II	47·4	66·7	17·4	60·4	74·2
CONTROL ..	114·1	..	..	134·6	..
(*C. olitorius*)					
Treatment I	27·8	98·1	22·8	38·4	99·4
Treatment II	44·4	81·5	14·4	56·3	79·1
CONTROL ..	125·9	..	..	135·4	..

47. A botanical and chemical study of *Euphorbia pilulifera* Linn.

A. B. BOSE *and* B. MUKERJI, Calcutta.

The dried entire plant of *Euphorbia pilulifera* is included in the British Pharmaceutical Codex and an extract of it is largely used in chronic bronchitis and other affections of the respiratory tract such as asthma and emphysema.

Several samples of crude drugs collected from various parts of India were examined botanically and chemically. In addition to generally described macroscopic characteristics, a transverse section of the stem presents the following characters under the microscope: Thick-walled wavy epidermis with hairs of two kinds; cortex consisting of 3 to 5 layers of cells with small groups of sclerenchymatous cells and oval cells interspersed, the latter being more prominent and containing latex; vascular bundle composed of phloem, cambium and xylem and parenchymatous cells containing large air-spaces forming the pith.

Average chemical composition—foreign organic matter about 4% and acid-insoluble ash, 0·63%. Both these figures are well within the standard laid down by the B.P.C.

Cytology and Genetics

48. Cytological studies on *Sesamum*.

A. ABRAHAM, Kayangulam (Trivandrum).

A wild *Sesamum* from Travancore is reported. It is shown that this is an indigenous species of great antiquity and possibly of wider distribution than now known. Though closely related to the cultivated *Sesamums* it is found to be distinct enough in certain important characters to deserve the rank of a separate variety. It is provisionally named as *S. orientale* var. *grandiflorum*.

The cytology of this variety is briefly described. The chromosome number ($2n = 26$; $n = 13$) is the same as in the cultivated varieties and the size of the chromosomes is also very nearly the same.

The following interspecific and intervarietal crosses made in this station are reported: (1) *S. orientale* var. *grandiflorum* × *S. orientale* (local) and reciprocally; (2) *S. orientale* var. *grandiflorum* × *S. prostratum* and reciprocally; (3) *S. prostratum* × *S. orientale* (local) and reciprocally.

The probable origin of the cultivated *Sesamums* is discussed and it is suggested that there were several distinct centres of origin, the Indian forms having arisen locally from the 26-chromosomed wild *Sesamum* now reported. Centuries of cultivation under widely different soil and climatic conditions must have led to the evolution of numerous distinct varieties

Only further cytogenetical studies in the Pedalinae could show clearly how the 26-chromosomed *Sesamums* originated.

49. Natural and artificial polyploids in Tapioca (*Manihot utilissima*).

A. ABRAHAM, Kayangulam (Trivandrum).

The cytology of a few varieties of Tapioca has been studied. The somatic chromosome number in ten varieties has been found to be $2n = 36$, and in one variety to be $2n = 32$. This confirms the observation of natural polyploidy in this plant, with 4 as the basic number.

The meiotic chromosomes have been studied in only one variety and the number is found to be $n = 18$.

Artificial polyploids have been induced in a few varieties by agar-colchicine treatment of the axillary buds. Completely polyploid branches, as well as sectorial and periclinal chimeras, have been obtained by this method. The polyploids showed the usual increase in size and deeper pigmentation of vegetative parts. In one treated variety which flowered, the flowers were also found to be larger than that of the controls. Induction of polyploidy has been confirmed by cytological examination which revealed 72 chromosomes in the apical bud in one branch.

Further studies on the polyploids are in progress.

The probable rôle of polyploidy in the evolution of numerous varieties of Tapioca is discussed.

50. Studies in jute. I. A few interesting observations in the root tips of nine types of jute.

P. R. PARUKUTTY, Calcutta.

The present paper deals with the nuclear structure and general behaviour of the somatic cells of the two species of Corchorus, viz. of

four types of *C. Capsularis* and five types of *C. Olitorius*. Prochromosomes were observed and their thickness in early stages and their comparative thinness in later stages are probably due to despiralization of chromosomes rather than the addition of chromatic material. Prochromosomes showed in certain instances definite tendency for pairing in the somatic cells. Binucleate cells and persistent nucleoli were observed in all the types investigated.

51. Effect of colchicine on root mitosis in plants.

SURAJ KRISHAN MALHOTRA *and* P. N. MEHRA, Lahore.

Effect of colchicine was tried on the root tips of *Nothoscordum fragrans*, *Zephyranthes* sp., *Ephedra foliata* and *E. intermedia*. The early outward signs of effect of colchicine is the swelling in the region of elongation and not in the region of active growth only in the first two plants. Colchicine causes the inhibition and dissolving of spindle mechanism, resulting in the scattering of chromosomes, thus facilitating in counting the exact number. Colchicine checks the divisional cycle of the cells, without effecting the division of chromosomes. The cells with tetraploids octoploid and 16-ploid chromosomes have been noticed in the root tip of *Nothoscordum fragrans*. The chromosomes also get condensed and shortened in size. The places of spindle attachment become clearer than in untreated material. The restitution nuclei are emulsoid and irregular in outline and often possess a large vacuole in the centre. The increase in the number of chromosome sets is associated with increase in cell size.

52. Colchicine induced auto-tetraploid *Argemone mexicana*.

SURAJ KRISHAN MALHOTRA *and* P. N. MEHRA, Lahore.

Colchicine treatment was given to the germinating seeds of *Argemone mexicana*—a wild plant of the Punjab plains. The success was gained with 0·3% colchicine for one day and two days' treatment. A cytological chimeral plant and a total polyploid have been obtained. The study of leaf epidermis, petal and sepal epidermis and pollen grains and also chromosome number has established the polyploid characters of the plant. The total polyploid plant produces a large number of sterile grains besides the larger one apparently fertile. In the chimeral plant, some leaves are total polyploid, others diploid while some are synthetic as shown by the cuticular studies. The seeds produced are bigger in size than in normal plant. Early signs of the effect of the drug on the germinating seeds are thickening of cotyledons, swelling of hypocotyl region and general slow growth of the seedlings. The normal diploid number for *Argemone mexicana* is 28 beyond doubt.

53. Chromosome number and morphology in some species of the genus Ephedra.

P. N. MEHRA, Lahore.

The chromosome number and morphology in seven species of the genus Ephedra has been worked out from the dividing body nucleus of germinating pollen grains. The basic number for the genus appears to be 7. Polyploidy has occurred in the genus, though not of high order, during the evolution of species.

Besides the normal haploid pollen grains, diploid grains are also observed in small percentage. The significance of these is discussed in the paper.

54. Colchicine and sulphanilamide effect on the mitotic division of body nucleus in the pollen grains in the genus Ephedra.

P. N. MEHRA, Lahore.

The effect of colchicine and sulphanilamide upon the division phenomenon of the body nucleus has been studied in detail.

The effect of sulphanilamide is exactly similar to that of colchicine in bringing about the collapse or inhibition of spindle mechanism. This results later in the formation of a double restitution nucleus or more than one nucleus of aneuploid constitution.

SECTION OF ZOOLOGY AND ENTOMOLOGY

President :—VISHWA NATH, M.Sc., PH.D. (CANTAB.), F.N.I.

Entomology

1. *Aedes* (*Stegomyia*) mosquitoes of Lahore and the bionomics of *Aedes* (*Stegomyia*) *aegypti*.

A. S. GOEL, Lahore.

Systematic studies of *Aedes* (*Stegomyia*) mosquitoes of Lahore were carried out during the last one year and the following species were recognized:—*Aedes* (*Stegomyia*) *aegypti*, *A.* (*Stegomyia*) *albopictus*, *A.* (*Stegomyia*) *vittatus*; *A.* (*Stegomyia*) *w-albus* and *A.* (*Stegomyia*) *unilineatus*. The first named, however, was the commonest species found. The distribution of these mosquitoes throughout the last year has been studied. In addition the breeding places were located. The life-history of *Aedes* (*Stegomyia*) *aegypti* has been studied under laboratory conditions, with special reference to its mating and feeding habits as well as oviposition.

2. Survey of paddy insects of Nizamabad district.

MOHAMED SULAIMAN VARASI, Hyderabad (Deccan).

Nizamabad is a promising district of Hyderabad State and is situated at a distance of 100 miles from the capital city. The famous Nizamsagar Canal constructed by H.E.H. the Nizam's Government runs through an area of 18 lakhs of acres of the district. It is mostly the paddy growing area of the State. The survey of the paddy insects of Nizamabad area was carried out and the following insects were found attacking the paddy crop in different periods of its age:—

Grasshoppers—Order *Orthoptera*: (1) *Hieroglyphus banian*, F. (2) *Lepisma* Sp. (3) *Aelopus tamulus*, F. (4) *Oxya velox*, F.

Beetles—Order *Coleoptera*: (1) *Haltica cyanea*, Wch. (2) *Aulocophora* Sp. (3) *Calandra oryzae*, L. (4) *Lytta temuicollis*, P. (5) *Oides affinis*, J.

Bugs—Order *Hemiptera*: (1) *Tetroda histeroides*, F. (2) *Leptocorisa acuta*, T.

Flies—Order *Diptera*: (1) *Atherigona* Sp. (2) *Pachydiplosis oryzae*, W.

Moths and butterflies—Order *Lepidoptera*: (1) *Schenobius incertallus*, W. (2) *Psalis securis*, Hb. (3) *Spodoptera mauritia*, B. (4) *Sesamia* Sp. (5) *Aneylolomia chrysographella*, K. (6) *Nymphula depunctalis*, Gr. (7) *Cnaphotocrocis medinalis*, G.

3. Structure of the reproductive organs in the termite *Termes redemanni* Wasm.

D. MUKHERJI *and* S. RAY CHAUDHURI, Calcutta.

The present paper is in continuation of the series on our study of the common mound-building termite *Termes redemanni* and gives the struc-

tural details of the reproductive organs of both the male and female commencing from the immature stage onward to the deälated stage.

The sex glands of both the male and the female are first distinguishable in the nymphs with wing-pads. In the larval forms prior to it, no sex gland has been found. In the nymph with wing pads, the oviducts run as a pair of cellular cord from which the ovarioles radiate in all directions in the form of a single row of cells linearly arranged. Ectodermal invagination on the ventral side in the region of the genital pore is also noticeable. In the sexual female at the winged stage, the ovarioles take their definite form. In the physogastric queen the oviduct is a long straight tube extending along the whole length of the abdomen. The ovarioles are radially arranged around the oviduct in which they open by separate apertures. Near the junction of the ovariole with the oviduct, i.e. in the calyx, a deposit of yellowish substance is seen. Two distinct types of glands shown by previous authors as sebifique glands, open into the common oviduct. The spermatheca which is a slender coiled tube also opens into the common oviduct.

With regard to the male the testes are first differentiated in nymphs with wing pads like spherical sacs filled with globular cells. In the deälated male found accompanying the physogastic queen the testis is composed of a large number of sacs which are spirally coiled to form a spherical mass, one on each side. Each sac can be differentiated into an apical portion opening into the vas deferens. The vas deferens, before it unites with its fellow on the opposite side, dilates to form the seminal vesicle. Copulatory organs are lacking.

4. Development of the silk-worm.

D. MUKERJI *and* SAUREN BANERJEE, Calcutta.

The embryonic development of the silk worm *Bombyx mori* (Nismo white and Nistid yellow variety) is studied in this paper. The seed-cocoons were supplied by the Sericulture Department, Government of Bengal and were reared in the University laboratory under normal room temperature. The eggs were fixed in regular intervals, in a lot of 30 at a time in Mukerji's fixative and stained in toto in Grenacher's Borax carmine. Sections were cut at different stages to trace the formation of embryonic membranes, endoderm formation and other parts.

The primitive streak is differentiated on the 12th hour after deposition. Sinking of the embryonic band commences first at the two extremities and starts on the 16th hour. The head and tail-folds become distinguished on the 36th hour. The embryo elongates from the 12th hour onwards up to 40th hour. Later, shortening of the band follows and at 72 hours the curvature disappears and the embryo lies straight. Stomodaeum and proctodaeum formation are completed at the 85th hour stage. Hatching takes place in the same room condition on the 7th day.

5. Embryonic development of the termite *Termes redemanni* Wasm.

D. MUKERJI *and* RAJENDRAPRASAD CHAUDHURI, Calcutta.

In this paper the embryonic development of the termite is studied. Eggs were collected at regular intervals throughout the year directly from the nests from the royal chamber. Eggs were fixed in the field with Mukerji's fixative and stained in toto in the Borax carmine solution, which gave best results. The stained preparations were then sorted out into different stages. The different stages were then cut into serial sections and studied.

The primitive streak occurs in the form of a cluster of cells towards one pole of the egg. The cells next arrange themselves into two layers

which separate out in the middle. The outer layer of cells forms the amnion and the inner layer the germinal epithelium. In the middle of the germinal epithelium a slight invagination takes place and from the invaginated point cells migrate inward into the neighbouring yolky portion to build the inner layer. Cells also separate out from the germinal epithelium at other points particularly at the extremities of the embryonic band to form the inner layer. The formation of mesoderm and mesoblastic somite, the fate of the embryonic membranes and the formation of the mesenteron are studied in successive stages.

6. Biology of *Helopeltis theivora* Waterh., the mosquito-blight of tea gardens (Heteroptera–Capsidae).

D. Mukerji, J. L. Bhaduri, D. P. Mukherjee *and* S. Ray Chaudhuri, Calcutta.

In the scheme of research on the control of tea-mosquito, *Helopeltis theivora* Waterh, carried on in the Calcutta University Laboratory and in the field laboratory at Katalguri Tea Estate, Dooars, under the University, financed by the Indian Tea Planters' Association, Jalpaiguri, the authors in course of their investigation report in this paper the results of their observations on the life-history, food selection and mechanism of feeding.

A survey of plants other than tea growing in the tea estates on which this insect feeds, deposits the eggs and completes the life-history is incorporated. Among the plants attacked the following are found: (1) *Amorphophallus campanulatus* Bl. (2) *Momordica cochinchinensis* Sprengl. (3) *Dolichos lablab* L. (4) *Carica papaya* L. (5) *Psidium guyava* L. (6) *Duranta plumieri* Jacq. (7) *Mangifera indica* L. (8) *Nyctanthes arborcristis* L. (9) *Gossypium* sp. (10) *Capsicum* sp. (11) *Cosmos bipinatus* Cav.

No marked deviation in the life-history of the insect was observed when reared on *P. guyava* and *N. arborcristis*.

In this paper the authors record also the results of their experimentation, which determine the nature and composition of food. The effect of synthetic food on the life-cycle of the pest was also investigated with a view to testing the main constitution of its food. The results of experiments to determine the rôle of acidity and alkalinity in the food as alluring agent are also given. Further, the authors concur with the previous views that the injury to the leaf caused during the feeding operation is mechanical.

7. Life-cycle and parasitism of *Dipleraus tachinida*, the larval parasite of *Sesamia uniformis*, Dudgn.

Mohamed Sulaiman Varasi, Hyderabad (Deccan).

Parasitism and the life-cycle of *Dipleraus tachinida* was studied in the Sugarcane Insect Pests Laboratory at Bodhan-Deccan.

The larvae of *Sesamia uniformis*, Dudgn. which were more or less grown up were found to be parasitized. The average number of days for the parasite to complete its life-cycle have been found to be 21. It took 10 days to obtain puparium and 11 days for the adult to come out of it. It was found that the parasitization was high in the months of February and March. The percentage of parasitism under laboratory conditions in the month of September was 33·33%, in the month of October 19·00%, in the month of November 42·00%, in the month of December 0·00%, in the month of January 0·00%, in the month of February 60·00% and in the month of March 67·00%.

8. Biology of *Stromatium barbatum* Fabr.

R. L. GUPTA, Nagpur.

The beetle is widely distributed. Its larva is a borer and is a pest of a large number of forest trees but also attacks a variety of trees in the plains. The recorded food plants are about 311 belonging to 54 different natural orders. In the Central Provinces it has been found to attack teak, *Acacia catechu*, mango, orange, lemon, *mosambi*, pomegranate, Haemotoxylin, *Casurina*, *Bauhinia variegata*, jack fruit and *Albizzia lebbek*. It is particularly a bad pest of citrus trees in the Central Provinces. Young citrus trees are not attacked but those over 12 to 13 years are infested, older ones being more susceptible. It is not only a dry wood pest but also a pest of green trees. A survey made in Nagpur of several orchards over 15 years old showed the attack varying from 75 to 80%. A full account of the life-history is given.

9. Insect pests of stored copra and tapioca in Travancore.

K. KARUNAKARAN NAYAR, Trivandrum.

This is a short note on the insect pests in stored copra and tapioca studied by the author, in connection with the Survey of the pests in stored products in Travancore.

Corcyra cephalonica, Staint., *Silvanus surinamensis*, L., *Tribolium castaneum*, Hbst., *Necrobia rufipes*, Fb., *Tyroglyphus longior var* : *castellani*., and *Solenopsis geminata*, Fabr., were found in stored copra; and *Calandra oryzae*, Linn., *Aroecerus fasciculatus*, deG., *Rhizopertha dominica*, Fb., *Gibbium* sp., and *Tribolium* sp., were found in stored tapioca.

10. Some insect pests of vegetables in the Travancore hills.

C. J. SELVA RAJ, Trivandrum.

A short account is given of the observations made on the insect pests of vegetables grown at Pampadampara, in the Cardamom Hills in Travancore. The author has observed the following pests on vegetables:

Xanthorhoe saturata, *Arcilasisa plagiata*, *Plusia orichalcea*, *Plutella maculipennis*, *Crocidolonia buiotalis*, *Athalia proxima*, *Prodenia litura*, *Pericabi ricini*, *Monolepta signata*, *Chalaeuosoma metallicum*, *Bagrada picta*, *Riptortus pedestris*, *Agrotis segetis*, *Hellula undalis*, *Crocidolomia suffusalis*, *Alphae biguttata*, *Dasychira mendosa*, *Orgyia postica*, *Cifuna* sp., *Plusia eriosoma*, *Cacoesia micacaeana* and a dipteran leaf miner on cabbage and an Eupterotid on 'Avarai' (*Dolichos lablab*). Brief descriptions on *Xanthorhoe saturata*, *Arcilasisa plagiata*, the *Eupterote* sp. and the dipteran leaf miner are given.

11. Biological control of *Eublemma amabilis*, a predator of lac insects, by one of its indigenous parasite, *Microbracon greeni*.

P. S. NEGI, Namkum.

The paper briefly brings out that in the biological control of indigenous injurious insects by their native parasites and predators the aim is to modify the condition of natural equilibrium already highly adjusted and to maintain permanently the readjusted equilibrium, while in the case of introduced foreign insects the aim is to build up a condition of natural equilibrium.

From among the other parasites and predators of *Eublemma* reasons to choose *Microbracon greeni* are discussed. It is pointed out that to control *Eublemma* by *Microbracon greeni* 'increase' of the parasite shall have to be maintained chiefly through liberations from laboratory rearing

rather than by 'conservation' of the parasite in the field; if it is found necessary to supplement such additions by 'conservation', the dry season lac crops (*Baisakhi* and *Jethwi*) shall have to be grown by artificial infection and wet season crops (*Aghani* and *Katki*) by natural infection.

The technique of the experiment is discussed. It is contended that to evaluate the success of the experiment the more important criterion is the comparison of the density of *Eublemma* population in treated and untreated area rather than parasitism percentage. A method has been evolved for such comparisons. The experimental data offered for six crops definitely indicates the possibility to control *Eublemma* by *M. greeni* through artificial releases to about 50% more than it naturally does.

12. Mango-hoppers.

KHAN A. RAHMAN, Lyallpur.

There are two species of mango-hoppers, *Idiocerus atkinsoni* Leth. and *I. clypealis* Leth., met with in the Punjab. Observations are in progress by which it is designed to find out the part played by the mango-hoppers in bringing about shedding of mango flowers and mango fruits in nature. Results of these observations are briefly summarized below: On an average a mango inflorescence has above 465 flowers, 94·4% of which are staminate, 5·5% bisexual and ·1% are pistillate. Even in the absence of mango-hoppers by far the greatest majority of these flowers are shed, only a very small percentage (5·2–6·6) of them setting fruits. As a result of mango-hopper attack practically all the set fruits are shed.

13. Cricket pests of germinating crops.

KHAN A. RAHMAN, Lyallpur.

About seven species of crickets are found damaging germinating crops in the Punjab. The most common of them are (1) *Gymnogryllus erythrocephalus* F., *Gryllulus* (*Gryllus*) *domesticus* Linn., *Liogryllus bimaculatus* DeGeer. They are popularly known as 'tidi' in the province, and *Gryllulus domesticus* is most familiar species in the lot.

The life-history and habits of *Gryllulus domesticus* were studied in great detail.

It can be successfully controlled by poisoned bran mash with sodium fluosilicate as poison. Common lizards, spiders, digger wasps (*Liris haemorrhoidalis* F. and *Notogonia* sp.) take a heavy toll of this insect.

14. Thysanoptera from Lyallpur.

KHAN A. RAHMAN, Lyallpur.

About 50 different species of thrips have been collected from the Punjab from 125 different food plants. Commonest and most important of these are briefly discussed below:—

(1) *Rhipiphorothrips cruentatus* H. This is the commonest of the thrips and has been recorded from grape-vine, rose, mango, *Terminalia arjuna*, *E. jambolana* and pomegranates. Rahman (1933) has studied it in detail.

(2) *Thrips tabaci* Lind. It is world-wide in distribution and is a serious pest of onions in the Punjab where it has also been found feeding on 13 different food plants belonging to the natural orders Cucurbitaceae and Malvaceae.

(3) *Heliothrips indicus* Bagnall. It is a serious pest of potatoes at Lyallpur. Also recorded from cabbage and cauliflower.

(4) *Stylothrips brevipalpis* Ky. This was collected from marigold flowers at Lyallpur.

(5) ***Anaphothrips citricinctus*** **Bagnall. This was found on sugar-cane and maize.**

(6) ***Thrips florum.*** **This was found in large numbers in the flowers of apple, peach, rose and jasmine.**

(7) ***Frankliniella sulphureq*** Schmutz. **This was found on the leaves of *Hibiscus esculentus*, ash gourd (*Benincasa cerifera*), water melon (*Citrullus vulgaris*), 'halwa kadu' (*Cucurbita maxima*), and in flowers of sannhemp (*Crotalaria juncea*), 'tori' (*Luffa aegyptaca*), 'sankukra' (*Hibiscus cannabinus*), 'karela' (*Memordica charantia*), 'ishkpecha' (*Convolvulus* sp.), rose and chillies from Lyallpur.**

(8) ***Isoneurothrips orientalis*** **Bagnall. This was found on rose and jasmine.**

The biology of *Thrips tabaci* Lind. has been studied in detail.

15. Hypermatomorphosis in *Acrocercops phaeospora* Meyr. (Jaman leaf miner) larvae.

KHAN A. RAHMAN *and* HARBANS SINGH PRUTHI, Lyallpur.

During these studies of *Acrocercops phaeospora* Meyr. hypermetamorphosis was observed in the caterpillar of this pest, and on further studying this point it was observed that the larvae can be differentiated into two distinct forms, namely, sap-feeding (I–IV instars) and tissue feeding (V–IX instars). The differences in the morphology of two divisions of caterpillars are illustrated below:—

1. *Sap feeding forms.*—Head is wedge-shaped, depressed, with arms of epistomal ridge not meeting posteriorly but joined by a transverse bar; antenna fairly prominent, mandibles flattened more or less spherical, maxillary palpi and lobes reduced. Spinneret absent, labial palpi vestigeal, superlinguae represented by two teat-like prominences; body flattened dorsoventrally, tapering posteriorly; meso, meta and III-IV segments furnished dorsally with transverse rows of conical and rectangular sclerites; thoracic and abdominal legs absent.
2. *Tissue feeding forms.*—Head is rounded with arms of epistomal ridge meeting posteriorly and forming an inverted V; antennae relatively short; mandibles triangular; maxillary palpi and lobes well developed, spinneret and labial palpi fairly prominent. Body cylindrical without any conical and rectangular sclerites on the dorsal side; three pairs of thoracic and four pairs of abdominal legs present.

16. Potato storage experiments against potato tuber moth in the Punjab.

KHAN A. RAHMAN *and* GURCHARN SINGH SOHI, Lyallpur.

In order to supply potato seed to the cultivators at cheaper rates for the autumn crop in the plains, the Department of Agriculture has undertaken the purchase and storage of local potatoes in the Kangra Valley as this seed is considered to be as good as the imported Patna seed. With the introduction of this new practice, the potato tuber moth which is a serious pest of stored potatoes in other parts of India has come into prominence and several cases of its severe outbreak have been reported during recent years, so much so that in 1940-41 this new venture was very seriously threatened by this insect. Since the success of this enterprise has a far-reaching effect on the cultivation of potatoes, especially during these days when due to transport difficulties it is not even possible to

import Patna seed, the preservation of potato seed against this insect has become an urgent necessity.

For this purpose extensive trials were conducted at Palampur and the potatoes were stored both on the pucca floor as well as on the racks with various covering materials of about one inch in thickness. It was found that saw dust, chopped lantana, bhusa proved very effective in checking insect infection. The average percentage of loss in weight due to insect attack as well as rotting was 4·6, 5·3, 5·6, 6·9, 7·0, 7·3 and 12·9 in case of tubers covered with saw dust, chopped lantana, bhusa, local grass, sand, soapnut leaves and pine needles respectively as against 61·3% in the control lot.

17. On the thickness of the thorax of *Apis indica* F.

KHAN A. RAHMAN *and* SARDAR SINGH, Lyallpur.

Queen excluders made in America and England and at Pusa are in common use among the Indian bee-keepers. We have also used these queen excluders and have found them to be unsuitable to the Punjab form of *Apis indica*. It was, therefore, decided to study the thickness of the thorax of the worker and queen honey bees, with a view to design a queen excluder suitable for the Punjab. This work was taken up last year and a special technique was evolved for this purpose. As a result of these investigations it was found that the thickness of the thorax of the worker bee varied from ·133" to ·141" and that of the queen bee from ·172" to ·180". Thus to be suitable in the Punjab, each perforation in a queen excluder should be less than ·160" wide.

18. The biology of the grain moth (*Sitotroga cereallela* Oliv.) in the Kulu valley.

KHAN A. RAHMAN *and* AMAR NATH SAPRA, Lyallpur.

Sitotroga cereallela Oliv. is a serious pest of stored wheat, maize and barley in the hilly tracts of the Punjab: at Kulu (4,000 altitude) it does the greatest damage to barley. Caterpillars hibernate inside the grains. The over-wintered caterpillars start pupation by the middle of April, moths from them emerging in the beginning of May. The pest completed 5-6 generations, which overlapped, during the course of a year.

The females lived for 4–10 days and laid 48–176 eggs in 3–8 days at the rate of 1–72 eggs per day. The eggs hatched in 4–11 days and the average viability of eggs was 57·25% during June when the atmosphere was hot and dry and above 88% during other months of the year. The males completed their life-cycle in 30–39 and females in 32–40 days. Of the various articles tried for preventing the females from ovipositing one inch thick layer of sand on the grain surface proved the most effective.

19. The longevity of the Indian bee (*Apis indica*).

M. C. CHERIAN *and* V. MAHADEVAN, Coimbatore.

A knowledge of the longevity of bees helps a practical bee-keeper in building up the strength of his colonies and maintaining the maximum force before the honey flow season. This aspect of study in the case of the Indian bee has so far received very little attention.

For longevity studies silver gilt powder mixed with spirit gum was used for marking bees. White enamel paint diluted with turpentine was also found as a good substitute.

The maximum longevity of the workers ranged from 44 to 54 days, the average being 50 days. The maximum longevity of the drones was 57 days while that of the queen was 3 years 4 months and 14 days.

20. Preliminary studies on the flight range of the Indian bee (*Apis indica*).

M. C. CHERIAN *and* V. MAHADEVAN, Coimbatore.

Successful production of honey in a locality depends upon the proper selection of site for the apiary based on a knowledge of the bee-pasturage as well as flight range of bees. For the studies on the flight range, the substance used for marking bees was the same as that used for longevity studies, viz. silver gilt powder mixed with spirit gum or white enamel paint diluted with turpentine. The bees were first attracted to the top of the frames in the hive by pouring a little honey and while they were in the act of taking the food their thoraces were touched with the paint with aid of a fine camel hair brush. A maximum of 8¾ furlongs was so far observed to be the flight range of the Indian bee.

A study was also made of the maximum distance bees were able to traverse to find out their hive. The entrance of the hive selected for the studies was closed by means of a wire gauze the previous night and the hive removed the next morning and kept at a known distance, with its entrance opened. An empty box with one of the brood combs was kept in the original place and the number of bees returning noted. A series of trials have shown that even from a distance of 13 furlongs some bees were able to return to the original place by virtue of their homing instinct.

21. On a new species of *Cryptotermes* from South India.

M. C. CHERIAN *and* V. MARGABANDHU, Coimbatore.

A description is given of a new species of *Cryptotermes* obtained from Goa damaging wood. The other two previously recorded species of *Cryptotermes* are *C. domesticus* Hav., collected at Trivandrum and *C. bengalensis* Snyder ex *Heritiera fomes* from Bengal. The new species can be differentiated from the former in the size of mandibles, and incised shape in front of head and from the latter in the shape of the anterior rim of head, the length of the third antennal segment, the general shape of head and body measurements.

22. On a new species of the subgenus *Lophoceratomyia* Theobald, 1905. (Diptera; Culicidae.)

M. A. U. MENON, Travancore.

The male and female of a new species of *Culex*, namely *C.* (*Lophoceratomyia*) *parainfantulus*, is described in detail. This species is allied to *C.* (*L.*) *minutissimus* (Theobald) and *C.* (*L.*) *infantulus* Edwards. The three species differ from one another mainly in the structure of the male hypopygium. The position and appearance of the phallosmal processes in the three species are quite unlike those found in other mosquitoes of the genus *Culex*.

Specimens of *parainfantulus* have been collected by the author from North and South Travancore. The females of the species are blood-suckers.

23. Insect pests of cardamom in Travancore.

S. JONES, Trivandrum.

The paper deals with the insect pests of cardamom observed so far in Travancore and the control measures against the important ones. The life-history and habits of the most important pest *Taeniothrips cardamomi* Ramakrishna Aiyar is given in detail. Other important pests like the hairy caterpillars (Eupterote spp.), the cardamom weevil (*Prodioctes haematicus* Chevr.), the cardamom root-borer (*Hilarographa caminodes*

Meyr.) are dealt with in some detail. Notes are given on eighteen minor pests and on the non-insect pests and diseases of cardamom.

24. Observations on the life-history of *Eupterote fabia* Cram (?) on cardamom.

G. Renga Aiyar, Trivandrum.

A detailed account of one of the two most important hairy caterpillar pests of cardamom in Travancore is given in this paper. Though this insect is seen throughout the cardamom hills and the neighbouring forest areas every year, it assumes the proportions of a serious pest only once in several years.

Each moth lays about 500 eggs on the under-side of the leaves of the shade trees in flat masses of about 50 to 160 eggs from June to August. The caterpillars that hatch out are about 2 mm. in length and begin to feed on the leaf. After the fifth moult they descend on to the cardamom plants on sunny days suspended by silken threads. They feed voraciously on the cardamom leaves by night and completely defoliate them. There are 10 instars within a larval period of 130–150 days. Pupation takes place in the loose soil at a depth of 1½-2 inches in a silken cocoon to which hairs and soil particles adhere. Pupal is from 6-7 months. Only one brood has been noticed in the year.

Cytology and Protozoa

25. Spermatogenesis of the cattle-louse.

Daljit Singh Sarkaria, Lahore.

The work on the spermatogenesis of the cattle-louse was started in May, 1943, with a view to find out the exact nature of the cytoplasmic components and their fate during spermateloosis. The lice were collected from buffaloes of Lahore and testes were fixed in diluted Flemming-without acetic. Sections 5-6μ thick were stained with ·5% iron-haematoxylin.

Spermatogonia, spermatocytes and maturing spermatids have been studied. The mitochondria appear as a vacuolated cloud in the early spermatocyte, which subsequently forms a prominent mitochondrial nebenkern. The Golgi apparatus appears as a single granule in the spermatocyte, and later in the spermatid directly gives rise to the acrosome. The latter is not a secretory product of the Golgi granule. The spermatocyte undergoes a strikingly unequal division with regard to the cytoplasm of the cell, which appears to be the only spermatocyte division. My observations confirm the findings of Doncaster and Cannon (1920).

26. Spermatogenesis of the guinea-pig.

Gian Chand, Lahore.

The work on the spermatogenesis of the guinea-pig was started with a view to investigating the exact nature of the 'post-nuclear body' (Gatenby and Wigoder, 1929) and the formation of the acrosome. Various fixatives were employed, but Flemming-without acetic followed by 5% iron-alum as mordant and ·5% haematoxylin turned out to be the best.

Preparations made with Flemming-without acetic have clearly shown that the large dictyosomes figured by Gatenby and Woodger (1921) at the periphery of the idiosome are artifacts due to the excessive deposition of silver or osmium. The real form of the Golgi elements in this material is granular, but the granules are so much over-crowded at the periphery of the idiosome body that they appear as dictyosomes in Cajal and Mann-Kopsch techniques employed by the authors. Indeed Meves (1899) in his

classical work on this material actually figures granules in the idiosome body.

The acrosome is directly formed by the fusion of the 'proacrosomic granules' of Gatenby and Woodger, which are really the Golgi elements.

The 'post-nuclear body' of Gatenby and Wigoder (1929) is in reality the dense posterior region of the nucleus as confirmed by Feulgen's reaction. This conclusion is in harmony with the results obtained by Friend (1935) in the sperms of the Muridae.

27. Spermatogenesis of *Porcellio* sp.

RAJ KUMAR JAIN, Lahore.

In this paper the author has described in detail the process of spermateleosis in *Porcellio*. The nucleus of the spermatid elongates, becoming concavo-convex and is bent over the growing tail. A part of the usually single Golgi granule transforms itself into the acrosome at the anterior end of the head; the rest is sloughed off as Golgi remnant. Six or seven neighbouring spermatozoa form a 'sperm colony'. The mature sperm has a long, ribbon-shaped head, bent over a fine, long tail.

The nature of the vacuole present in the nucleus of the spermatid and the young spermatozoon, the bent head, and the 'sperm colony' have been discussed and also their significance.

28. On the so-called post-nuclear body.

G. W. VAIDYA, Lahore.

Friend (1935), working on the sperms of the British Muridae, described that there was an asymmetrical deeply staining area in the posterior part of the nucleus in all the Muridae sperms he had seen, which gave the characteristic stain with Feulgen. He named this area as the 'dense posterior region', and pointed out that in position it agreed with Gatenby's 'post-nuclear body' (Gatenby and Wigoder, 1929).

Working on the sperm of the squirrel, *Sciurus palmarum*, I have confirmed Friend's conclusions. I employed Feulgen's reaction on smears and sections fixed in about seventeen fixatives. The posterior part of the nucleus in each case took up the characteristic stain, showing that the 'post-nuclear body' is only a part of the nucleus. In Da Fano (Chilled) preparations no post-nuclear granules were observed in any stage of spermatogenesis, but in Da Fano smears silver was deposited on the posterior part of the nucleus.

29. Spermatogenesis of the fowl-tick, *Argas persicus* (Oken).

GANPATI PARSHAD SHARMA, Lahore.

My work on the spermatogenesis of the cattle-tick, *Hyalomma aegyptium* (Linne) and the dog-tick, *Rhipicephalus sanguineus* (Latreille) has already been reported. (*Proc. of the 29th and 30th Ind. Sci. Cong.*, 1942 and 1943). The present work deals with the spermatogenesis of the fowl-tick, *Argas persicus* (Oken).

A detailed study of spermateleosis in all the three species revealed that the so-called 'apyrene' sperms described in the previous communications are in reality the intermediate stages in the formation of the normal 'eupyrene' sperm. The mature sperms are formed by a very complicated and two-fold process of invagination and evagination. The former process takes place in the male and the latter in the uterus of the female.

Spermatogonia, spermatocytes and the early spermatids have the usual thick striated limiting membranes round them. The mitochondria are distributed throughout the cytoplasm in the form of pale fine granules. The Golgi elements in the form of rings and crescents are also beautifully

preserved. The acrosome is directly-formed by the fusion of the Golgi elements and is not a secretory product thereof.

30. The chromosomes of *Gegenophis carnosus* Bedd.

B. R. SESHACHAR, Bangalore.

The chromosome complex of this Apodan example has been analysed. The diploid number as seen in the metaphase plate of the primary spermatogonium is 30, which can be grouped as follows:—

(a) V-shaped chromosomes:	Small V's	..	12
	Large V's	..	8
(b) Rod-like chromosomes	..	..	4
(c) Dots ..	..	..	6

This number and form of the chromosomes are confirmed by the examination of the meiotic metaphase plates. In the first division, there are 25 bivalents, of which the larger are multiple and compound, formed by the large V-shaped chromosomes. The smaller chromosomes form simple tetrads. The metaphase plate of the second division shows the reduced number of chromosomes, i.e. 15 each with two chromatids. The formation of multiple compound tetrads by the larger V-shaped chromosomes is a feature found in the other two examples of the Apoda examined (*Ichthyophis* and *Uraeotyphlus*). It is generally found in the Urodela and only rarely in the Anura (*Alytes* and *Bombina*).

A comparison of the chromosomes numbers of *Gegenophis* with those of *Ichthyophis* and *Uraeotyphlus* shows at first a wide variation. But the application of Robertson's law shows that *Gegenophis* is closely related to the other genera of Apoda.

31. Studies in coccidia from frogs and toads.

M. CHAKRAVARTY *and* A. B. KAR, Calcutta.

This paper contains an account of the morphology of two new coccidia, *Isospora stomaticae* n.sp. and *Eimeria cyanophlyctis* n.sp. Of the two coccidia the former is found in the intestine of *Bufo stomaticus* and the latter in the same organ of *Rana cyanophlyctis*. Both the hosts were collected from the suburbs of Calcutta. A short account of the morphology of the coccidia is given here. In *Isospora stomaticae* n.sp. the oocysts are broadly oval in shape and measure $24{\cdot}2\mu \times 15{\cdot}4-20\mu$. The oocystic. wall, though double-layered. is very thin. Neither oocystic residuum nor micropyle is present. The sporocysts are egg-shaped and measure $15{\cdot}4-17{\cdot}6\mu \times 11\mu$. A sporocystic residuum is present. The sporozoites are elongated bodies and measure $13{\cdot}2\mu \times 3{\cdot}3\mu$. In *Eimeria cyanophlyctis* n.sp. the oocysts are oval in shape with very thin and transparent oocystic wall which is single-layered. They measure $19{\cdot}8-15{\cdot}4\mu \times 17{\cdot}6-15{\cdot}4\mu$. There is no micropyle but an oocystic residuum is present. The sporocysts are single-shaped and measure $11\mu \times 6{\cdot}6-4{\cdot}4\mu$. Diffused sporocystic residuum is present.

32. Observations on *Eimeria barbeta* n.sp., from the blue-throated Barbet *Cyanops asiatica* (Lath.).

A. B. KAR, Calcutta.

In this paper the author describes in detail the morphology of a new coccidian *Eimeria barbeta* n.sp. which he obtained from the intestine of the blue-throated Barbet, *Cyanops asiatica asiatica* (Lath.), purchased from a local bird dealer. Briefly described the morphology is as follows: The oocysts are oval in shape and measure $22-24{\cdot}2\mu \times 19{\cdot}6-19{\cdot}8\mu$. There is no oocystic residuum but a micropyle is present. The sporocysts are oval in shape with one of the ends more pointed than the other and measure

19·8μ. A sporocystic residuum is present. The sporozoites are elongated bodies with one end pointed and the other rounded. They measure 15·4μ × 8·8μ.

33. Studies on a variant of *Trypanosoma evansi* in a buffalo.

S. V. MUDALIAR, Madras.

In the blood of a buffalo a small trypanosome much different from the usual *Trypanosoma evansi* in morphology, was met with, when the animal was undergoing treatment in the Veterinary Dispensary, Royapuram, Madras. A casual observation suggested the possibility of the organism being very similar to *T. vivax*. It measured on an average 21m., had a blunt and rounded posterior end with the kinetoplast at or very close to the posterior end and a short flagellum with ill-developed undulating membrane. Biological experiments were undertaken and the result of the study of the organism in the laboratory small animals as well as on a sheep, goat and a calf, revealed characters different from those of the usual type of *T. evansi*. In consideration of the morphological and biological differences noticed compared with the usual type of *T. evansi*, the organism is thought to be a variant of *T. evansi*, if not an entirely new one. It is proposed to name it *Trypanosoma evansi var rayi*.

34. On a new flagellate, *Trichomonas hystrixae* n.sp., from the caecum of Himalayan porcupine.

H. N. RAY *and* S. N. SAPRE, Mukteswar.

A new species of flagellate, *Trichomonas hystrixae* n.sp., is described from the caecum of porcupines at Mukteswar-Kumaun, U.P. The distinguishing features are: (1) the free flagella run along the folds of the undulating membrane and become detached posteriorly; (2) the nucleus is rectangular and lozenge-shaped; (3) in dimension it is bigger than the hitherto known species of *Trichomonas* from rodents. The dimensions are as follows: 17μ to 34μ × 8·5μ to 17μ.

35. The present position of cattle surra in India and some problems connected with the disease.

H. N. RAY, Mukteswar *and* S. V. MUDALIAR, Madras.

The course of bovine surra in inoculated animals and in cases of natural infection has been dealt with. In the former it is found to run a chronic course with the organisms appearing at very infrequent intervals, in very small numbers and finally disappearing from the animals' circulation without about six months; while natural surra of the bovines is very virulent, runs an acute course in the form of outbreaks and is attended with as many as even 90% of mortality. From this it is doubted if both the organisms are the same or different from each other.

The possibility of bovines acting as reservoir hosts for dissemination of surra among animal has been examined.

The transmission of surra from the diseased to healthy bovines or other animals is only direct or mechanical by biting flies through interrupted feedings, the interval between the feeds not exceeding a few minutes. No cyclical development in any of the biting flies *Tabanus* or *Glossina* has been noticed so far and probably this does not exist.

Cattle form the reservoir host in addition to the camel where the latter is found commonly and the period when cattle can act as the reservoir host may not be more than six months.

Methods of diagnosing the carriers are described. Treatment is also described.

Fishes

36. The feeding habits of *Wallagonia attu* (Bloch.).

A. PARAMOO, Trivandrum.

The present paper gives a brief account of the feeding habits of *Wallagonia attu* and some of the common varieties of fish found in the Jumna. In studying food habits, the best method to be adopted is to visit fish-markets, and, after identifying the fishes found there, secure the entire alimentary system for later analyses. In 26 specimens of *Wallagonia*, varying in length from 2′ 4″ to 3′ 8″, 132 young fishes were counted. In two of the specimens human remains and in one remains of a rat were detected. In a single specimen, measuring 3½ feet, 15 young fishes were counted. A table showing the results of analyses is given. This would indicate that *Wallagonia attu*, which is generally believed to be a scavenger-fish, is primarily a predator which indiscriminately feeds upon young fish and causes considerable injury to the valuable fresh-water fisheries of the Gangetic system. The control of this fish seems to be a very essential factor in any scheme for the development of fisheries.

37. On the ecology and fish-fauna of the Pákhal lake.

B. K. DAS, Hyderabad (Deccan).

Pakhal is the largest fresh-water lake in the Hyderabad State and situated 17° 57′ N. : 79° 59′ E. in the Warangal district (on the eastern part of the State), and made by throwing a dam (about 4,300 ft. in length) across the river Pákhal, which is formed by the union of 5 streamlets arising from the low hills of the Balaghat range. The lake is 8,000 yds. by 6,000 yds., with an average depth of 30 ft. to 40 ft. and having a surface area of 13 sq. miles, meant chiefly for irrigation purposes.

The fishes have been captured in the shallow parts of the lake, at the sluice gate and also in the larger channels and nallahs connected with it, generally by means of circular cast net, small triangular hand-net and the bag-net, the last-named was especially fixed at the sluice-exit of the dam. On the whole, the lake is fairly rich in its fresh-water fish-fauna—37 species of fishes, belonging to one dozen families, have so far been discovered during the preliminary survey.

38. Studies on leptocephali of Madras coast.

R. GOPALA AIYAR, M. MUKUNDAN UNNY *and* P. M. VARKEY, Madras.

The study of development of the eel has been made classic by the wonderful researches of Schmidt. That the European eel *Anguilla vulgaris* and the American eel *Anguilla rostrata* grow in European and American rivers and go down to the Atlantic and return as elvers after a prolonged larval period as leptocephali has been well established. Very little, however, is known regarding the breeding of the Indian fresh-water eels, such as *Anguilla bengalensis*, *A. bicolor* and *Ophichthys boro* except for scattered references of their occurrence in some of the Indian rivers. Similarly, we know very little about the breeding habits of the Indian marine eels, such as *Muraenesox cinereus*, *Uroconger lepturus*, etc. The present paper deals with a small collection of eel eggs obtained from the plankton very recently, and the leptocephali collected during the last few years. The latter apparently belong to different genera of eels. One type of leptocephalus has been observed to metamorphose into *Muraenesox cinereus*. Another belongs to *Ophichthys boro* as revealed by myotome counts of the leptocephalus, elver and adult though actual metamorphosis has not been observed. Other leptocephali have also

been examined but have not yet been definitely correlated with their adults.

39. A study of the dentition of the Elasmobranchs of the Madras coast with special reference to the successional theory of teeth.

R. RAGHU PRASAD, Madras.

Fishes are generally polyphydont. In Elasmobranchs, as the functional teeth are lost those of the next series move outwards and the whole phalanx of teeth is restored. Thus there is a constant marching onwards of the teeth from behind. This widely accepted theory has been questioned by Cawston. He believes that wherever there is replacement it is by vertical succession. Comparative studies of the dentition of the adults and embryos of several Madras Elasmobranchs were made and it was noted that reserve teeth are arranged in series one behind the other. It has also been observed that there is regular wear and tear of the front teeth. Young healthy specimens of *Tryogon uarnak*, *Narcine timlei* and *Chiloscyllium griseum* with portions of the dental armature removed, were kept in the aquarium tanks and periodically examined. It was noted that after a time the dental armature was completely replaced. Sections also revealed that there are no tooth germs immediately below the functional teeth and that replacement of lost teeth is effected by the rolling forwards of the teeth from behind.

40. Pelagic fish-eggs and larvae of the Madras coast.

M. A. JOHN, Madras.

Correlation of the common pelagic fish-eggs and larvae with the adult fishes found in Madras coast has great economic value. The present paper, in addition to giving the diagnostic characters of the several of the common fish-eggs of Madras plankton, deals with developmental stages of eggs, larvae, and post-larvae obtained during the years 1934–1936. Eggs of *Clupea leiogaster*, *Stolephorus* sp., *Engraulis* sp. and *Solea humilis* have been described along with their developmental stages obtained by their hatching out in the laboratory. Larval stages of *Elops indicus*, *Megalops cyprinoides*, *Opisthopterus tartoor*, *Arnoglossus tapeinosoma*, *Psettodes erumei*, *Plagusia marmorata*, *Sciaena aneusi*, *Leiognathus insidiator*, *L. linfolatus*, *L. ruconius*, *Triacanthus brevirostris*, *Plotosus anguillaris* and *Amphisile scutata* are also described. The paper also gives a brief account of the food and feeding habits of the fish-larvae studied.

41. On the spawning habit and early development of *Oryzias melastigma* (McClelland).

H. K. MOOKERJEE *and* S. P. BASU, Calcutta.

The spawning habit of *Oryzias melastigma* (McClelland) has not been touched by any previous worker, but according to Kamito (1928) in the allied species *Oryzias latipes* of Japan, the spawning takes place in bright daylight. Recently Solberg (1942) has experimentally proved that spawning can be had readily with powerful electric light in addition to daylight. But the Indian species *melastigma* behaves in the reverse way and prefers absolute darkness instead of bright daylight for spawning. It never spawns during the day except artificially in dark room. The processes of oviposition and insemination are described in detail.

According to Kamito (1928) the allied species *latipes* is cannibalistic in habit, but the Indian species *melastigma* is absolutely free from such vicious propensities.

Regarding the early egg stages a point worth recording is that the previous authors Raj (1916), Jones (1937) and Job (1940) have stated that the egg of *Oryzias melastigma* has only one oil globule, but really each egg has 30 to 40 oil globules to start with, which ultimately coalesce into one. The other details of the embryonic stages have been dealt with recording many interesting points of observation.

42. Bionomics of the big-jawed jumper, *Lactarius lactarius* (Cuv. & Val.).

D. W. DEVANESEN *and* P. I. CHACKO, Pamban (Madras).

The big-jawed jumper contributes to an important fishery from June to January. It is piscivorous, no less than nine species of fish having been recorded from its stomach-contents. The male fish attains maturity when it is 16 cm. in size, whereas the female attains maturity when 18 cm. in size. The females preponderate in the commercial catches. The spawning season, September and October, coincides with the peak of the fishery.

43. The silver-bellies of Pamban.

P. I. CHACKO, Pamban (Madras).

Six species of *Leiognathus* and one species of *Gazza* contribute to the fishery of silver-bellies in the shallow sea around Pamban, from November to May. These fish are plankton feeders, but *Gazza minuta* occasionally feeds on fingerlings of white-bait (*Stolephorus* sp.). The spawning season extends from November to February. There are eight species of carnivorous fishes which feed on silver-bellies. Yet the fishery does not show signs of depletion.

44. Cultivation of milk-fish in Krusadai Island.

D. W. DEVANESEN *and* P. I. CHACKO, Pamban (Madras).

The milk-fish, *Chanos chanos* (Forskal), is a common marine fish, which lends itself easily to artificial cultivation. The saline swamp of Krusadai Island has been converted into a marine Fish-Farm, with sluice gates to regulate the ingress and egress of the seawater during the flood and ebb tides. The fingerlings are collected from the neighbouring creeks and bays, and transplanted into the ponds of the farm. The plankton brought into the farm by the flood tide is found to be suitable and sufficient to form the food of the impounded fingerlings. The latter feed on this plankton and the plant complex growing on the swamp. The natural enemies of the fingerlings are periodically eradicated. The average size of the fingerlings at the time of impounding is 50 mm., and these grow in the farm at the remarkable rate of 28 mm. per month.

45. A note on a collection of fishes from River Kistna.

M. RAHIMULLAH, Hyderabad (Deccan).

Some fishes and other aquatic animals from the River Kistna have been described including *Mystacoleuces ogilbii* (Sykes), of which many stages were obtained from shallow waters. Young ones of *Barbus* (*tor*) sp. have also been reported.

46. Colour changes in the developing stages of *Mystacoleuces ogilbii* (Sykes).

M. RAHIMULLAH, Hyderabad (Deccan).

Colour changes in different stages of *Mystacoleuces ogilbii* (Sykes) have been dealt with. It is shown that in the smallest specimen there are

a number of black vertical bands descending to the ventral profile which gradually diminish in size and finally disappear in the adult specimens.

47. Fish fauna of Lingampalli channel.

SYED MAHMOOD, S. A. KABEER *and* A. K. DAS, Hyderabad (Deccan).

Lingampalli channel which starts from the overflow of Hussainsagar was surveyed in the month of April 1943. Fishes, aquatic organisms, and vegetation along with pH and temperature have been noted. Special mention has been made of *Oryzias melastigma* which is reported for the first time from Hyderabad State. Other larvicidal fishes have also been mentioned.

48. Fish survey of the River Musi.

WALI HYDER HUSSAINI *and* R. A. HUMAYUN, Hyderabad (Deccan).

A survey of the fishes of River Musi was conducted in the month of May 1943. An account of the fishes along with pH and temperature of water is given. Formerly it was considered that the water of this river was too dirty for the sustenance of fish life, but it has been shown that only a very small part is devoid of fish and other portions contain many useful species for stocking.

49. The blind fishes of Travancore.

K. KRISHNAN NAIR, Trivandrum.

Four species of blind fishes have been recorded from Travancore. Of these two are new to science, viz. *Amphipnous* sp. nov. and *Taenioides* sp. nov. *Amphipnous* sp. and *Taenioides* sp. are recorded from South India for the first time. *Trypauchen vagina* (Bloch and Schneider) is also recorded for the first time from Travancore, while *Symbranchus bengalensis* (McClelland) has been recorded before from Malabar. All these blind fishes have more or less similar habit of life. They live either in pits or burrows. The burrowing forms, like *Amphipnous* sp., *S. bengalensis*, are completely worm-like and are devoid of lateral appendages, whereas the pit-dwelling forms, *Taenioides* sp. and *Trypauchen vagina*, have fish-like appearance and lateral appendages. But like the burrowing forms they are also more or less blind. The habit of dwelling in burrows or pits seems to have been responsible for the development of aerial respiration. In the burrowing forms, while capacity to store air in their bronchial cavities is necessitated by their burrowing mode of life which hinders gill respiration. in the case of pit-dwelling estuarine forms aerial respiration is necessary because the pits or crevices in which they dwell are often exposed and laid bare when the tide recedes.

50. On the physiology of the pyloric caeca in a herbivorous fish, *Osphronemus gorämy* Lacép.

A. K. DAS *and* M. RAHIMULLAH, Hyderabad (Deccan).

Biochemical analysis of the contents of the stomach, pyloric caeca and intestine was carried out in this herbivorous fish. It has been shown that the stomach secretes *pepsin* and pyloric caeca *diastase* and *trypsin*; while *maltase* and *trypsin* are secreted by the intestine and some other enzymes come from the pancreas. Bile was also present inside the lumen of the caeca.

51. Further remarks on the digestive enzymes of *Ophicephalus striatus* Bl.

A. K. DAS *and* M. RAHIMULLAH, Hyderabad (Deccan).

Enzymes from the lumen of the pyloric caeca in this carnivorous fish were reported last year. It has now been shown that the stomach secretes *pepsin*, intestine maltase and *trypsin* and the caeca secrete *lipase* and *trypsin*. The secretion of *lipase* in this fish instead of *diastase* in the case of Goramy is due to its carnivorous diet.

Helminthology

52. Some fresh-water Turbellaria from Kashmir lakes.

GURAN LAL ARORA, Lahore.

The author collected fresh-water Turbellaria from high mountain lakes in Kashmir when he accompanied the two Zoological Excursion Parties to the High Lake Region in 1940 and 1941. The present paper deals with a systematic account of some of the forms with special reference to their ecology. The animals described belong to the order Tricladida, family Planariidae.

53. On a new trematode *Eucreadium eutropiichthyius* n. gen., n.sp. from a fresh-water fish *Eutropiichthys vacha* (Ham.)

J. DAYAL, Lucknow.

A number of trematodes were collected from the intestine of *Eutropiichthys vacha*, obtained from a tank at Lucknow. The trematodes belong to the family Allocreadiidae but differ from all the known genera in the relative position and structure of the testes, ovary and cirrus sac. They also differ from others in the position of the genital pore and in the possession of operculated eggs which are pointed at the anopercular end. A detailed description of the form is given in the paper.

54. On a new trematode *Neopodocotyle indica* n. gen., n.sp., from the intestine of a fresh-water fish *Callichrous bimaculatus* (Bloch).

J. DAYAL, Lucknow.

A number of trematodes (*Neopodocotyle indica* n. gen., n.sp.) were collected from *Callichrous bimaculatus* obtained from River Gomti. The new forms are closely related to *Podocotyle* (Allocreadiidae) and resemble it in the relative position of the ovary and testis, in the position of the genital pore and in the structure of the cirrus sac. The new form however differs from it (*Podocotyle*) in the position of the ventral sucker which in this form is near the anterior sucker. It also differs from *Podocotyle* in the extension of the uterus behind the ovary, and the relative size of the organs. A detailed description of the new form (*Neopodocotyle indica* n. gen. n.sp.) is given in the paper.

55. On a new species of the nematode genus *Thubunaea* Seurat.

G. K. CHAKRAVARTY, Calcutta.

A new nematode worm of the genus *Thubunaea* has been recovered from the stomach of *Gekko gecko* collected from the suburbs of Calcutta. A detailed description of the worm has been dwelt upon in this paper.

56. Occurrence of *Criconema rusticum* Micoletzky, 1921, in Travancore.

R. PARAMESWARA IYER, Trivandrum.

Criconema rusticum is a soil nematode collected from Central Travancore. It is recorded in India for the first time, and so far only the females have been described. They are found in the soil among the roots of sugarcane and, though they have strong and prominent stylets capable of piercing roots, they have not so far been found inside roots. The body is short and stout (0·313 mm. to 0·46 mm. in length and 0·022 mm. to 0·06 mm. in width) and is marked by a series of distinct annulations roughly 4 to 5μ apart, and 88 to 89 in number. Unlike other soil nematodes it appears to be somewhat sluggish and incapable of active movements, when isolated and taken on a slide. A brief description of the morphology and the bionomics of the nematode has been included in the paper.

57. An interesting trematode parasitic in an Indian marine food fish.

H. D. SRIVASTAVA, Izatnagar.

During the examinations of marine food fishes at Karachi in 1936, the author discovered the parasite described in this paper. It is assigned to a new genus owing to several characteristic features which distinguish it from the known trematodes. The parasite has a subcylindrical body with a prominent, muscular, cup-shaped structure at its anterior end. The oral sucker is situated at the base of this cup and, in dorso-ventrally flattened specimens, it comes to lie at the base of a deep oral vestibule formed by the cup. It may also be everted at times when the cup-shaped structure assumes the form of a prominent, muscular collar round the anterior end. Prepharynx and oesophagus are absent, pharynx is present. The intestinal caeca are broad and have prominent shoulders; the two caeca open independently to the outside through two ani at the posterior end of body. Acetabulum is very small and is situated about the middle of body length. The excretory bladder is a broad, elongated sac-shaped tube, whether or not it bifurcates anteriorly into cornua has not yet been definitely made out. Cutaneous gland cells are profusely developed all over the body but spines are absent. Gonads are intercaecal and situated in the posterior half of body. They are fully described. The genital pore is pre-acetabular. The name *Cryptocephalus* is proposed for this genus with *C. indicus* as the type species.

58. On the occurrence of *Psilochasmus longicirratus* Skrjabin, 1913, in *Nyroca ferina* in India.

N. B. INAMDAR, Dharwar *and* G. D. BHALERAO, Izatnagar.

A member of the genus *Psilochasmus* (Psilostomidae, Trematoda) has been recorded for the first time in India. Observations have been made in detail on the anatomy of the worm and variations occurring in certain respects have been recorded. In view of these variations the validity of some of the species assigned to the genus has been argued.

59. A new species of Avian cestode, *Ophryocotyloides bhaleraoi* n.sp., from the purple-rumped sunbird, *Cinnyris zeylonicus* (Linn.).

N. B. INAMDAR, Dharwar.

While engaged in examining a collection of cestodes made during past few years, I came across this worm. On examination I find

it to belong to the family Davaineidae, sub-family Ophryocotylinae Fuhrmann, 1907, and genus *Ophryocotyloides* Fuhrmann, 1920.

On comparison with the other described species of this genus, I find the variations to be sufficient to create a new species to which I propose the name *Ophryocotyloides bhaleraoi*.

60. Two species of the nematode genus *Setaria* Viborg.

M. M. SARWAR, Izatnagar.

Observations have been recorded to prove that *S. cervi* (Rud.) and *S. digitata* (V. Linstow) are two distinct species. *S. digitata* has more or less quadrangular lips while in *S. cervi* they are triangular. The appendages in the posterior part of *S. digitata* are bluntly rounded and the knob varies from a vestige to a well-defined rounded one.

61. An account of two species of lungworms from Indian goats.

M. M. SARWAR, Izatnagar.

Two new lungworms, one of the genus *Protostrongylus* Kamensky and the other of *Varestrongylus* Bhalerao, are described. The spicules in *P. indicus* n.sp. are distinct on account of the characteristic shape of their posterior end. *V. capricola* n.sp. differs from *V. pneumonicus* by the absence of a spindle-shaped gubernaculum. The validity of the application of the term gubernaculum to dorsally situated structure is discussed.

62. On some helminths of the fowl, mainly from India.

G. D. BHALERAO, Izatnagar *and* N. S. KRISHNA RAO, Mandya.

The paper deals with six nematodes and seven cestodes. *Acuaria pavonis* Ortlepp is considered to be a synonym of *A. hamulosa*. *A. spiralis*, *Raillietina rangoonica*, *R. grobbeni*, *Hymenolepis cantaniana* have been recorded for the first time in India. *Capillaria columbae*, so far known from pigeons, has been recorded from poultry. *Heterakis beramporia* and *R. echinobothrida* have been recorded from Singapore. *Tetrameres mohtedai* n.sp. and *Bhalfilaria badamii* n.g., n.sp. have been described in detail and arguments for regarding them new to science have been given. Remarks are offered on the species *Cotugnia digonopora*, *Amoebotaenia sphenoides* and *R. tetragona*. Interesting variations have been recorded in some species dealt with.

63. An appeal to systematic helminthologists in India.

G. D. BHALERAO, Izatnagar.

It has been a general practice of all systematic helminthologists in this country to publish abstracts of their papers in the *Proceedings of the Indian Science Congress* and in doing so some new species, new genera, new sub-families and rarely new families are proposed. Since the Indian Science Congress does not publish full papers, the descriptions of the new genera and new species, etc. are published subsequently by the authors in some journal, sometimes a few years later. In doing so, however, the authors do insist on attaching the symbols 'n.g.', 'n.sp.', etc. to the forms whose names have already appeared in the *Proc. Ind. Sci. Cong.* This is altogether a wrong procedure, and imposes on other workers the onus of discovering whether the name has been previously published or not. In order, therefore, to facilitate the work of other systematists on this group the authors are requested 'either not to attach a new name to a species or a genus, etc. mentioned in an abstract before the publication of the full description, or else, when publishing a full description later, not

to label the species, genus, etc. as "new" but to quote the earliest appearance of the name'. This appeal is made at the suggestion of one of the eminent helminthologists of Great Britain, Dr. H. A. Baylis.

General

64. Histology and development of the corpus luteum in *Rhinobatus granulatus* Cuv.

(MISS) MARY SAMUEL, Madras.

Various views are held in regard to the mode of formation of the corpus luteum, and the origin of the luteal cells in mammals. The present communication describes the manner in which the corpus luteum is formed, and traces the origin of the luteal cells in a typical ovoviviparous Elasmobranch—*Rhinobatus granulatus*.

A detailed description of the histology and development of the corpus luteum from the earliest stage up to the formation of a solid granular body is given. All the three elements of the follicular wall of the ruptured Graffian folicle, viz. follicular epithelium, theca interna and theca externa take part in the final formation of the corpus luteum.

The luteal cells are shown to be formed by the hypertrophy of both the cells of the follicular epithelium and the theca interna. Their mixed-origin of the luteal cells is described in a lower vertebrate for the first time.

It has also been shown that degenerative changes set in very late. The close analogy between the formation of the corpus luteum in the Elasmobranchs and the mammals is pointed out.

65. Formation of the spermatophore in some South Indian pulmonates.

P. N. RAJAKRISHNA MENON, Annamalainagar.

The formation and transference of the spermatophore has been studied by the author in *Ariophanta ligulata* (Fer.), *Ariophanta bistrialis* (Beck.), *Xesta* (Fretun.) *semirugata* (Beck.), and *Euplecta subdecussata* (Pfeiffer). A complete series of stages in the formation of the spermatophore have been obtained and sketches of these are given in the paper. The formation of the spermatophore is in the kalc-sac, epiphallus and caecum as well. The function of the caecum is to form the tail or narrow end of the spermatophore and to help the transference of the spermatophore and 'not to receive the spermatophore before it enters the penis sheath' as Dasen described. 'Calc-cells' in which crystals of arragonite are formed are found in abundance in the connective tissue of caecum, and during the formation of the spermatophore they are shed into the lumen of the caecum. Calcareous granules are formed in the kalc-sac, epiphallus and in the connective tissue of the penis. The calcareous granules are moulded into a compact case for the sperms.

Further observations are in progress.

66. Chaetognatha of the Travancore coast.

N. KRISHNA PILLAI, Trivandrum.

The phylum *Chaetognatha* is represented in the Travancore coast by three genera—*Sagitta, Spadella* and *Krohnia*. The genus *Sagitta* which is the most predominant comprises five species, of which *S. enflata* and *S. bedoti* are fairly common, whereas the remaining species are somewhat rare and are only occasionally found in the plankton. In the present paper, the species *S. gardineri* described by John from the Madras coast and Lele from the Bombay coast have been shown to be synonymous with *S. enflata* described by Fowler. *S. enflata* described by John from the Madras coast is evidently some other species.

The genus *Krohnia* is represented by a single species, *K. pacifica*. This was recently described from Indian waters by Varadarajan and Chacko. But it has been shown that the *Camera lucida* sketch given by them as well as their description seem to disagree with the type description given by Fowler and the characters noticed in the present collection.

Spadella draco has also been recorded; but it is very rare, probably because it is a form which usually remains attached to the smooth surface of sea-weeds and other sub-marine growths.

67. Effect of vitamin A deficiency on the female reproductive system with special reference to albino rats.

(MISS) MARY SAMUEL, Madras.

It has long been known that the absence of vitamin A in the diet of rats interferes with ovulation and fertilization, causing sterility in the female. This work is an attempt to find out whether there are any deviations from the normal in the histological structure of the ovary, uterus and vagina—deviations which can be reasonably attributed to deficiency of vitamin A in the diet causing sterility. Important histological changes in the vagina and uterus have been described.

68. Physiology of excretion in the earthworm.

K. N. BAHL, Lucknow.

Our knowledge of the physiology of excretion of the Oligochaeta is still very incomplete. As recently as 1938 Stolte Broun's Tierreich says that each one of the number of contributory processes involved in excretion has been investigated with varying results, so that it is not possible as yet to have a complete picture.

The author has discussed in this paper the part played by the chloragogen cells and the body-wall, the coelomic fluid and the blood, and the nephridia in excretion. He also describes the nature and mass of excretory products.

69. On the nephridial system of the Indian carnivorous leech *Haemopis indicus* Bhatia.

M. L. BHATIA, Lucknow.

Haemopis was for the first time recorded from India by the author in 1940.

In the matter of testis-sacs *Haemopis* occupies an intermediate position between *Hirudo* and *Hirudinaria*, there being 10 pairs in *Haemopis* 9 and 11 respectively in *Hirudo* and *Hirudinaria*.

The general layout and gross features of the nephridial system are very similar to those of *Hirudo* and *Hirudinaria*, described by the author in *Q.J.M.S.*, 1938.

Of the 17 pairs of nephridia from VI to XXII segments, 6 pairs are in the pre-testicular segments, 10 pairs in the testicular segments, and 1 pair in the post-testicular segment. Nephridia are thin and delicate, and the different lobes are much spread out. The initial lobe is an extensive structure, massing round the ampullae which enclose the ciliated organs.

Eleven pairs of ciliated organs, enclosed within the perinephrostomial Haemocoelomic ampullae, have large ciliated funnels, and like the other two forms are subservient to the Haemocoelomic system.

Detailed comparison with the nephridial system of *Hirudo* and *Hirudinaria* is given in the paper.

70. On the skeleton of the common Indian frog, *Rana tigrina*.

M. L. Bhatia, Lucknow.

Although the number of zoology textbooks for the Indian students has multiplied considerably during the last few years, it is not possible to entirely depend on any one book which figures or describes accurately the skeletal system of the common type *Rana tigrina*.

This paper, illustrated by a number of figures, gives a detailed description of the entire skeleton.

The cartilaginous part of the cranium, the cartilages of the nasal capsule, the septo-maxillary bones mentioned by Bhatia and Prashad (*P.Z.S.*, 1918) are accurately sketched and described. The foramina for the cranial nerves, the attachment of the lower jaw and the hyoid apparatus are properly determined. The ear-bone, *columella*, is described in detail.

In the pectoral girdle the edges of the coracoids of the two sides, differently figured in the textbooks, partially overlap in the mid-ventral line. Detailed structure of the girdle including the cartilages is figured and described.

71. On the alimentary canal and gonads in *Microcosmus manaarensis* Herdman, a monascidian from Madras.

S. M. Das, Lucknow.

All the specimens of this species were secured by Herdman from the coast of Ceylon or from the Gulf of Manaar. No other record of this ascidian exists. It is now recorded from the coast of Madras. The present paper gives a first description of the alimentary canal and the gonads in *Microcosmus manaarensis*.

The specimens on which the author has worked contain no sand and shell fragments on or in the test—a specific character mentioned by Herdman. It thus substantiates the author's earlier view that (i) the presence of sand, shell fragments, etc. attached to or incorporated in the test, and (ii) the formation of a thick '*foot*' of test substance for attachment of the animal are not standard specific characters, but vary from individual to individual, depending on the nature of the substratum on which the ascidian lives.

72. On variations in the number of gonads and shape of dorsal tubercle in the monascidian *Styela areolata* Heller.

S. M. Das, Lucknow.

That large specific variations occur in the lower chordates is an established fact. The author shows that in *Styela areolata* Heller the number of gonads varies from three to seven on the right side and one to three on the left, and that the number of gonads should not be regarded as a specific character in *Styela*. Incidentally, this is the first time that such a large variation in the number of gonads is recorded in *Styela areolata*.

The shape of the dorsal tubercle, which is considered by some authors as a specific character, also shows variations. The present paper contains the first record of *Styela areolata* in the coastal waters of the Indian main land.

73. A note on the cephalic segments of the embryo of *Caridina laevis* Heller.

K. Bhaskaran Nair, Trivandrum.

This small fresh-water shrimp occurs in plenty in the ponds in and around Trivandrum. Brooded specimens can be easily obtained during the monsoon months. Each brood contains on an average 30–40 embryos.

The eggs are large measuring about 1 mm. in length and half as much across. They are heavily yolked and the developing embryos are attached to the pleopods of the mother. The early embryology of the form has been studied and the methods employed were the same as in the two previous investigations of the author on *Mesopodopsis* and *Squilla* (*Proc. Ind. Acad. Sci.*, 1939, 1941). Interesting results have been obtained.

74. The fresh-water prawns of Baroda (a preliminary report).

S. T. MOSES *and* P. H. JOSHI, Baroda.

Fresh-water prawns in the fish supply of Baroda City, viz., *Palaemon carcinus*, Fabr. and *P. malcolmsonii*, Milne-Edw., have been described in this paper.

75. Further cases of abnormalities of the vascular system of the common Indian frog, *Rana tigrina* Daud.

THAKUR S. B. SINGH, Nagpur.

The paper is an attempt to place on record the abnormalities in the circulatory system of the common Indian frog, *Rana tigrina*, which is dissected in the various Indian Universities as a type for vertebrate anatomy in the junior classes. The abnormalities appear irrespective of the sex of the frog. These are chiefly affecting the anterior as well as the posterior veins. Work of this type has been done on the European frog, *Rana temporaria*, but the abnormalities recorded in this paper are absolutely new ones than those previously recorded. The anterior venous abnormalities are chiefly affecting the precaval veins, and its tributaries; while the posterior abnormalities are chiefly those of the renal portal vein and its tributaries.

76. Upanishads in the light of modern biology.

K. A. PATWARDHAN, Indore.

Man tried to interpret nature in terms of anthropomorphic concepts; these, however, failed to satisfy the thinking mind and the principle of causation emerged. This did explain the large scale phenomena but when science comes with closer grips with nature we have to admit that we are not yet in contact with the ultimate reality. A comparison of the advance in scientific thought today and in the vedic period shows that we are no better than the scientists of those times who had not only reached the modern stage of the search of the ultimate reality but had gone much further. This would appear amazing but it is true and intensive research alone could prove this. As a proof the full scientific interpretation of one 'Upanishad' (Aitareya Upanishad) is given which shows that this is a volume which deals with questions which are fully biological dealing with subjects like (*a*) origin of life, (*b*) evolution of a higher animal, (*c*) differentiation of structure correlated with function, (*d*) evolution of the vertebrate nervous system, (*e*) facts about gametes and the phenomena of fertilization, (*f*) definition of life and its evolution, and (*g*) method of attaining the supreme bliss. It is suggested that some effort is made by the State, Universities or the Science Congress to organize intensive research in this direction.

77. On the fluctuation of a few typical items of planktonic organisms in the sea around Krusadai Island, Gulf of Manaar, for the quinquennium 1936-37 to 1940-41.

D. W. DEVANESEN *and* P. I. CHACKO, Madras.

The following items were selected for the study: Copepoda, *Leucifer*, Pteropoda, *Sagitta*, Larval bivalves, *Coscinodiscus*, *Chaetoceras*, *Rhizo*-

solenia, *Thalassiothrix* and *Trichodesmium*. The periodical rise and fall of these organisms during the five years have been studied by means of graphs. The Zooplanktonic organisms dominate the hauls. Copepods maintain the highest level between the 'plenty' and 'common' stages. The Pteropods occupy the lowest level between 'common' and 'rare' stages. Of the Phytoplanktonic organisms, *Trichodesmium* occurs abundantly, fluctuating between the 'swarms' and 'common' stages, falling to the 'few' stage on a few occasions. All the organisms, except *Chaetoceras*, contribute to the food of the following fishes of local fishery importance: the Indian Sprat (*Sardinella gibbosa*), the Sardine (*Pellona brachysoma*), the Gizzard-Shad (*Anodontostoma chacunda*), the White-Bait (*Stolephorus* spp.), the Rainbow-Sardine (*Dussumieria hasseltii*), the Milk-Fish (*Chanos chanos*), the Pink-Perch (*Synagris japonicus*), the Silver-Bellies (*Leiognathus* spp. and *Gazza minuta*), the Moon-Fish (*Mene maculata*) and the Mullets (*Mugil troschelii* and *M. waigiensis*).

78. Observations on the habits of two spiders mimicking the red ant.

A. P. Mathew, Trivandrum.

The paper contains observations on two ant-mimicking spiders, the Attid *Myrmarachne plataleoides* and the Thomisid *Amyciaea forticeps*, which mimic the common red ant *Oecophylla smaragdina*. The external forms of these spiders are compared with their model. *Amyciaea* is alleged to raise the first pair of legs to simulate the ant's antennae, but this is denied. It keeps both the first and second pairs of legs bent and quivering in a characteristic manner serving to 'lure' the ants. The usual statement that by ant-mimicry ants mistake these for other ants, thus affording these spiders plenty of unsuspecting prey, cannot be accepted in view of the discriminating powers of the *Oecophylla*.

Both these spiders are diurnal and their night retreats are described. *Amyciaca* 'sleeps' suspended on a 'sling' made for the night. Mating of *Amyciaea* is not preceded by any courtship as sometimes suggested—the 'nervous' movements noted when they come together being observed also as they ordinarily move about.

Purpose of ant-mimicry in both these is protective. In *Amyciaea* it is also aggressive. For protection through mimicry it is essential that the mimic be amongst or near the models. How this is brought about is discussed.

79. Systematics and distribution of Brackishwater lamellibranchs of Travancore backwaters.

P. M. Gokulapala Menon, Trivandrum.

The class Lamellibranchiata is represented in the backwaters of Travancore by eight genera, comprising eleven species. On these, *Ostrea*, *Villorita*, and *Meretrix* are of economic importance. The flesh of these three types is used as food, while the shells of *Meretrix* and *Villorita* form the main source of lime supply of the State. *Sanguinolaria diphos* and *Tellina ala* are recorded for the first time in Travancore. Old shells of *Arca granosa* and *Placuna placenta* are also found as subsoil deposits in the south-eastern region of the Vembanad Lake. The occurrence of these old marine shells tends to prove that the Vembanad Lake was once part of the sea and that it was converted into a backwater only during recent times. No mention of the Lake is found in the works of either Pliny or Periplus, which give a detailed account of the topography of the coast line as it existed in the first century of the Christian era. The presence of extensive subsoil deposits of *Villorita* six to seven miles away

from the main body of the lake in the region now called Kuttanad also indicates that the lake was much wider and more extensive than it is now.

80. On oviposition as a character in the evolution of terrestrial gastropoda from aquatic gastropod molluscs.

A. R. RANJAH.

The present paper describes the transition from aquatic to terrestrial oviposition in some gastropod molluscs, as reflected in the oviposition of the different species of *Pila*.

It also exposes the mistaken conception of Ryder that the egg of *Pila* resembles that of a bird by the presence of (1) an air vesicle, (2) a peripheral zone of more liquid albumen, and (3) a central solid mass of albumen. The author has proved that the air vesicle is a later structure which appears only in those eggs that are either exposed to direct sunlight or are not provided with enough moisture to cope wtih excessive evaporation. *It is never present in fresh eggs.*

Lastly, it disproves the statement of Scott (1934), who attributes the transformation of the outer or peripheral solid and opaque albuminous sphere into a transparent fluid to the physical conditions of the atmosphere, viz. light and heat. It is shown that it is due to an internal physiological process rather than to external physical atmospheric conditions.

81. A new device for the collection of moth eggs.

A. R. RANJAH.

The present paper gives a description of a cage devised to collect flour moth eggs. It is cylindrical in shape and consists of three separate pieces. The upper piece or cylinder has wire-gauze plates at its two ends with an entrance hole in the centre of the upper one for introducing the *Corcyra* moths. The lower cylinder has a funnel filled into it, at the bottom of which is a small removable or sliding cup in which the eggs get collected automatically. The whole thing is placed in a dish, which constitutes the third piece and contains water so as to prevent the access of ants to the eggs.

82. Mechanism of defence in a Pselaphognathous Diplopod, *Unixenus padmanabhii* Jones.

S. JONES, Trivandrum.

The genus *Monoxenus* was created by the writer (*Zool. Anz.*, Vol. 119, pp. 138–146, 1937) to include a new Pselaphognathous Diplopod (Fam. Polyxenidae); but recently it has been brought to his notice that this name has been previously used in zoology for a Cerambycid (*Monoxenus*, H. Kolbe, *Ent. Zeitung Stettin*, Vol. 54, p. 255, 1893. Coleoptera: Cerambycidae). Therefore, in the place of Monoxenus the generic name *Unixenus* with *Unixenus padmanabhii* Jones as the type is proposed.

Stink glands and calcified exo-skeleton are absent in the Pselaphognatha, but is provided with a covering of setae which are considered as protective. The paper deals with the muscular mechanism that helps to spread the post-anal bundle of defensive setae of *Unixenus padmanabhii* when irritated. The concave setigerous plate gets converted into a convex one by eversion when the two sets of muscles responsible for this contract. The defensive setae which are barbed and hooked are very feebly fixed on to the exo-skeleton enabling them to get themselves easily detached on contact with any object.

83. Descriptions of some new species of coccids found on sugarcane.

S. Ram Mohan Rao, Mukteswar.

In this paper detailed descriptions are given of *Pseudococcus radicicola* n.sp., *Phenococcus sacchari* n.sp., *Pseudococcus cuttackensis* n.sp. and *Rhizococcus radicicola* n.sp.

84. On a new monophlebus *Drosichiella giganteus* n.sp. from India.

S. Ram Mohan Rao, Mukteswar.

The descriptions of the male and female of *Drosichiella giganteus*, an apparently new species of monophlebus from India, are given in this paper.

SECTION OF ANTHROPOLOGY AND ARCHAEOLOGY

President:—VERRIER ELWIN, M.A. (OXON), F.R.A.I.

1. Foreign and outlying tribes in Epic India.

NANIMADHAB CHAUDHURI.

The Rāmāyaṇa and Mahābhārata cover a period of Indian history extending to nearly a millenium beginning with pre-Buddhistic times when Northern India was politically organized into sixteen States and ending with the early Gupta period when Huna incursions commenced. Foreign tribes that entered India during this period, the Persians, Yavanas or Yonas, Sakas, Palhavas, Tusaras, Chinas and lastly Hunas, all appear in the Epics, though the texts take no notice of the political changes that the irruption of the different tribes involved. Together with these foreign tribes there appear a number of outlying tribes whose number varies in different lists and the Mlecchas, probably non-Aryan speaking tribes regarded as outcastes. References show that most of these foreign and outlying tribes had come quite early under the influence of the Brahmanical religion and social system and many of them were regarded as Kṣatriyas who had become Śūdras. These tribes appear again and again but almost exclusively in connection with military exploits, they fight in the armies of indigenous princes and send tributes to the Central power. This is most likely reminiscent of the Maurya or rather of Gupta India, and it is against this background that the Mahābhārata portrays the picture of a prehistoric, forgotten conflict between the Kurus and Pāñcālas in which princes are described as taking part, some of them with Yavana, Saka and Chinese troops in their armies. As against this gigantic canvas spread out before us the Rāmāyaṇa is much less representative of India as a whole.

2. The Aryas, Dasas and Dasyus in the Ṛgveda.

NANIMADHAB CHAUDHURI.

The most important division of the people in the Ṛgveda is between the authors of the hymns and their enemies and not between Aryans and non-Aryans. Their enemies included both Aryas and Dasas. The Aryan enemies were opposed to Indra worship. The Dasyus had different rites, were non-sacrificing, worshippers of false gods, haters of ṛṣis. Agni had degraded them for not keeping fire and Indra had deprived them of the name of Arya. Several Dasa chiefs are named but with the exception of one, no other Dasa tribe appears to be mentioned by name. Similarly, though individual Aryas are named it is not stated which of the Ṛgvedic tribes were regarded as Arya. The third division is between the worshippers of Indra and the Indra-less. Among the Indra-less there were Aryas, deities and Dasas. Some priestly clans were associated with tribes inimical to Indra. Most of the Ṛgvedic tribes fought against Sudas the faithful Tritsu chief. The fourth division is between the white-skinned and the black-skinned. The friends of Indra are once spoken of as being white but whether *kṛṣṇa, kṛṣṇa-yoniḥ, kṛṣṇagarbhāḥ* really refer to the Dasa is doubted; on the contrary, Trasadasyu, an Arya, is once called the leader of the brown-skinned. From the above we are led to the conclusion that the Dasas of the Ṛgveda were probably tribes who belonged to an Aryan

stock different from the stock to which the priestly clans belonged and that the priestly clans branded them as Dasas and denied them the name Arya for their heterodoxy.

3. The Pamirian Alpines in the Indus valley in chalcolithic times.

NANIMADHAB CHAUDHURI.

The presence of the brachycephalic Indo-Aryans from the Pamirs in the Indus valley in chalcolithic times when the Indus civilization flourished is proved by craniological evidence and the evidence of a new mode of fractional burial. The presence of this 'Aryan' element among the population of the Indus valley has been ignored by theories advanced regarding the authorship of the Indus civilization which give all credit to the Mediterraneans and Armenoids for the Indus culture, it being held that the irruption of the brachycephalic Indo-Aryans from the Pamirs displaced the Indus civilization. Analysis of the elements of the Indus religion, however, does not support such a view. Some of these elements are peculiar to India and they disprove the theory of wholesale transplantation of the Mesopotamian culture in the Indus valley. Many of these elements appear deeply embedded in the Vedic tradition and these could not have been borrowed from the Medito-Armenoids whose representatives appear in Northern Indian records not earlier than the fourth century B.C. Many other elements with the characteristic Indus mode of representation reappear in the two religions which originated in Eastern India, Buddhism and Jainism. Some elements reappear with new accretions in the Epic religion which arose in the West. It is therefore a justifiable conclusion that the brachycephalic Indo-Aryans who are now represented by the inhabitants of the outer countries were an integral part of the Indus population and mainly responsible for the development of the Indus religion, that the Ṛgvedic priestly clans borrowed several elements of this religion from them and that they carried the tradition of the Indus religion along with them as they dispersed to the east, west and south from the Indus valley.

4. Primitive aboriginal cultures in the Deccan.

CHRISTOPH VON FURER-HAIMENDORF, Begumpet.

In the course of anthropological research in Hyderabad I have studied some of the aboriginal populations which represent the most ancient existing racial and cultural strata of the Deccan. The Chenchus, in whose physical type the Malid element is predominant, are one of the few Indian tribes persisting in an economy based on food-gathering and hunting. Life in small, semi-nomadic groups of fluctuating composition, the family as the principal social and economic unit, an almost complete absence of any institutional co-operation outside the circle of its members, a pronounced individualism are characteristic features of the Chenchus' social order. Economically the Chenchus stand on the level of palaeolithic man, and there is good reason to see in them a remnant of the races responsible for the palaeolithic flake-industries found in the Deccan.

But are there among India's aboriginals any tribes whose cultures can be correlated with the proto-neolithic civilizations characterized by the sausage-shaped or oval axe-head? The makers of these protoneolithic axes must have lived on a higher level of material development than the nomadic food-gatherers and hunters and there can be little doubt that they did not subsist entirely on the wild produce of the forests, but had begun to raise food-crops. Aboriginal tribes on a corresponding level of material culture exist still in the Deccan and the Eastern Ghats. The Hill Reddis of Hyderabad, for instance, stand midway between food-gatherers and fully fledged agriculturists; they cultivate on hill-slopes cleared of forest

with the help of no other implement than axe and digging-stick, broadcasting small millets in the ashes and dibbling jawari and maize. Thus their agriculture is far more primitive than the hoe-cultivation of the Austroasiatic peoples and many of the Gond tribes, and the gathering of wild-growing fruits and tubers plays an important rôle in their economy.

5. Indian megaliths with special reference to Pudukkottai.

K. R. SRINIVASAN.

The numerous megalithic sites in Pudukkottai bear a striking relation to its physical features. Here are all the resources that an iron age man needed for his megaliths, pottery, iron and ornaments and also traces of ancient glass and iron-smelting industries. The surface indications are stone-circles, cairns, dolmens and cromlechs, erected over urn or cist burials. While it would appear that neither the later Indus people nor the Vedic Aryans, known from Sanskritic sources, were responsible for the spread of either the megalithic cult or iron in India, ancient Tamil literature gives indications that iron was used in South India for a long time before the Vedic Aryans came there and that the megalithic cult was practised in South India from at least B.C. 1000. The survival of this cult and the knowledge of iron among some primitive tribes in the south and Central India would suggest an earlier period probably B.C. 2500–2000. The Egyptian origin of this cult and its probable spread from the south to the north have been postulated with reference to the density of the distribution of the sites and other considerations.

Instances of the association of these burial sites with ancient Buddhist, Jaina, and city sites are quoted and a correlation of the finds in the two sets of sites occurring near each other may yield fruitful results.

6. Use of myths in the religious practices of the Mundas of Chotanagpur.

M. BHADURI, Dharamjayagarh.

Magic and religion are often found in combination and utilized in the primitive as well as in the higher cultures, to secure escapes from fear and impending danger.

Incidents in personal or national experience of unexpected events resulting in miraculous escapes from imminent dangers were often the foundations of the conception of God as 'deliverer'. Thus originated the prophets and Avatars to relieve the sufferings of humanity from the forces of evil. Gradually, the great religions of the world enunciated as a cosmic principle that such divine manifestations occur periodically. There are examples in the primitive culture, of a practical use of the myths connected with their Gods. A section of the Mundas of Chotanagpur believe in the efficacy of the recital of the myth describing the triumph of their Supreme God Sing-Bonga over the Asurs—a race of great iron smelters who scorched the earth and made human life impossible.

7. Mahomedan blood groups.

D. N. MAJUMDAR, Lucknow.

Analysis of Blood Group data from the Muslim population of the U.P. shows their Blood Group distance from the Muslims of Bengal who have recorded similar Blood Group percentages as some of the lower castes of the area (Macfarlane). The large percentage of O among the Muslims of U.P. and a lower incidence of B show perhaps a higher degree of isolation or ethnic purity of upcountry Muslims.

8. The nasion-subnasion-basion angle in south Indian skulls: a criterion of maxillary projection.

A. ANANTHANARAYANA AYER *and* K. SANJEEVA RAO, Madras.

A study has been made of the nasion-subnasion-basion angle in sixty South Indian skulls, comprising 49 male and 11 female skulls. The average value is 85·5° in the male, and 84·9° in the female skulls.

The nasion-subnasion-basion angle is the antero-inferior angle of the superior gnathic triangle devised and described by Cameron. The superior gnathic triangle is drawn on paper from the measurements on skull of basion-nasion, basion-subnasion and nasion-subnasion lengths obtained by calipers. The nasion and basion are recognized standard anthropometric landmarks. The subnasion, a new point introduced by Cameron, is determined as 'the point where the line connecting Hrdlicka's subnasal points crosses the median plane of the skull'.

Maxillary prognathism can be resolved into two elements: (1) a nasal element dependent on the configuration of the body and frontal process of the maxilla, and (2) a subnasal element dependent on the depth and inclination of the alveolar process. The nasion-subnasion-basion angle is a criterion of the nasal element of prognathism. There is cause to believe that the nasal element of maxillary prognathism is a more reliable standard for assessing the evolutionary status of the face than the variable subnasal element or even the gnathic index.

The nasion-subnasion-basion angle shows a progressive evolutionary increase among animals and human types. According to Cameron its value is 78·6° in native Australian, 79·6° in male Negro, 81·6° in male Mongol, and 81·8° in male white. The present study shows that the South Indian female skull has an angle of 84·9° and the South Indian male skull an angle of 85·5°.

9. An Indo-classical custom.

C. R. KRISHNAMACHARLU, Madras.

The paper is meant to draw attention to the Indo-classical parallel festival of school-boys going door to door singing songs and receiving presents. The festivals were, however, held in different seasons in India and Rhodes.

10. Prehistoric microbone tools from Gujarat.

H. D. SANKALIA, Poona.

During the excavation of microlithic sites at Hirpura and Lãnghnaj both in and adjacent to the Sãbarmati valley, Northern Gujarat, by the Gujarat Prehistoric Expedition (1941-42), a large number of bone splinters, almost all fossilized were noticed usually between 2 feet to 6 feet. The writer examined each lot as it emerged, and found that some of these splinters showed clean pointed facets, while few others had a nib-like point and body. He consequently thought that pieces were probably small bone tools, prepared in imitation of microliths, in whose association they were found.

From the manner of cutting, the tools may be divided into the following eight types:—

1. Rectangular pieces, cut obliquely at one end.
2. Rectangular pieces, cut obliquely at both ends.
3. Rectangular pieces with spatulate end.
4. Pieces triangular in section with obtusely cut point.
5. Nib-like pieces with sharp long point and broad body, slightly convex on face and concave inner side.
6. Crescentic pieces with blunted arc and smooth chord and sides.

7. Thick crescentic pieces smooth all over, as if by rubbing, but showing original facets.
8. Burin-like objects, with their points cut obliquely as well as in a reverse fashion.

Probably these are the first bone finds of microlithic type in India or elsewhere, which are definitely recognized as tools. Till now bone tools of the later Palaeolithic, particularly the Magdaelenian and of the Mesolithic period from a number of sites in Northern Europe, Britain, Palestine, Africa (the Wilton of Kenya and Rhodesia), Ceylon and India are known. But all these are much larger in size and cannot be compared with Magdalenian and Magalmose bone tools.

11. Mother-right in Kerala.

L. A. Krishna Iyer, Trivandrum.

The mothers are the basis of the primitive social group. Mother-right means inheritance in the female line with regard to relation as well as property. Kerala is one of the important tracts where the principal matriarcally influenced social groups are found. Among the primitive tribes one section of the Malapantārams who lead a nomadic life, affords an example of the earliest form of patriarchy. There was no well-defined system of inheritance among them as there was nothing to inherit; the relationship that existed was patriarchal. When the tribes passed from the hunting to the agricultural stage, patriarchy developed into matriarchy. So it is among the Kanikkar, Muthuvan, Mannan, Malayarayan, Paraya and Pulaya among whom there was no change of clanship after marriage. But husband and wife retained their own clan, and the children belonged to the mother's clan. The clan is still the pillar of their social structure. In regard to inheritance of property, inheritance is in the female line among the Muthuvans, Mannans, and Thantapulayas.

Mother-right was at one time general throughout South India. The clan consisted of all descendants in the female line of a common male ancestor. The household was constituted by the mother and her children, sisters and brothers. Children belonged to their mother's brother whose name occurs in theirs. Degeneration set in, when, under the effect of modern civilization, the tendencies of the educated section began to draw them to the universal system of patriarchy. In 1926 a law was enacted regulating marriage, succession, and family management of the Nayars. Among other things, it altered the customary law of inheritance by conferring the right of inheriting a Nayar male's self-acquired and separate property on his wife and children, and made provision for the partition of the clan's properties among its members. This paved the way for the complete overhauling of the social organization of the community. While the regulation sounded the death-knell of matriarchy, the community which formed the backbone of the State has been disrupted and divided. The Nayar community has begun to pause to take stock of the situation. From the social point of view, matriarchy cannot be regarded as inferior to patriarchy. The two regulations of early civilization, matriarchy and exogamy, have nothing about them that is fantastic, outrageous or absurd, but are the practical outcome of the practical purposes of people like-minded with ourselves.

12. Distribution of palaeolithic cultures in India.

D. Sen, Calcutta.

Palaeolithic core-tools, flake and blade tools occur extensively in different parts of India. Of these, the blade industries, however, are not so well known as the core and flake industries. It seems to the author that the vast number of known and newly discovered palaeolithic sites in India may be fruitfully grouped on a regional basis. An attempt has been made

in this paper by the author to mark out a number of characteristic palaeolithic culture regions of India. If the local sequences, both typologic and stratigraphic, of the cultures in each of these regions be worked out in some details and the results correlated, a more or less complete picture of the sequences and movements of the palaeolithic culture history of India may be reconstructed.

13. Baradeo of the Gond.

(MISS) DURGA N. BHAGVAT, Bombay.

The paper discusses the nature, function and origin of this prominent Gond god.

Though he is the chief god of the Gond, as the prevalent religious practices and legends of his origin reveal, he is also worshipped outside the Central Provinces, and by other tribes than Gond. The god thus is known by many names and the ritual also varies from tribe to tribe and the place to place. As for example, the sacrificial victim of the god is the cow according to indigenous Gond tradition, and other tribes offer him a white goat or a pig or even a fowl. The implications of worship also are different.

Conclusion: The various legends of Baradeo and his cult point out that (1) the human origin of the god is probable, (2) his real victim is the cow, and (3) he is connected with the cult of the dead.

14. Godamuri: A fertility cult of North Kerala.

M. D. RAGHAVAN, Madras.

A ritual play of the character of a fertility cult is the folk play popularly known as 'Godamuri', prevailing in certain parts of North Kerala. The players are Malayans, the professional 'devil-dancers' of the district. The central figure is a boy in a girl's make-up, enclosed in a framework of the spathe of the areca palm, modelled in the shape of a cow. A number of men wearing grotesque masks and a drummer accompanying form the rest of this frolicsome company. The play as now performed is described in this paper with extracts from the folk-song accompanying the performance.

15. Vedan and Adi Padal.

M. D. RAGHAVAN, Madras.

Vedan and Adi Padal are quaint ceremonials of a communal and folk character, whose house-to-house visits enliven the dark and listless days of the very wet month of Karkitakam (June-July) in parts of North Kerala. The ceremonials are of an invocatory character, invoking divine blessings on the household. The paper gives an account of the custom and of the associated folk-songs.

16. Mesolithic industry at Sawyerpuram in the Tinnevelly district of Southern India.

A. AIYAPPAN, Madras.

Foote collected a small series of chert and quartz artifacts from the red sand dunes (*teris*) of Sawyerpuram and expressed then the hope that a closer search would be fruitful of results. The author recently made a collection of mesolithic artifacts from the Sawyerpuram *teris* which shows that this area was the centre of a well-developed upper paleolithic industry. The Sawyerpuram industry contains a very high percentage of quartz and chert blades and a smaller number of points, scrapers and awls. The collection also includes special types of borers, an extremely fine chert

arrow-head, a chert saw, and fine lunates of limpid quartz. The Sawyerpuram artifacts are smaller in size than the typologically mesolithic tools of the Nellore area included in the Manley collection. Though greater use has been made at the former locality of chert and quartz, the two localities bear ample evidence of common lithic traditions.

17. Anthropology and human genetics.

P. G. SHAH, Bombay.

The study of Anthropology in India has made rapid strides and the progress recorded by Dr. B. S. Guha in the Indian Science Congress Jubilee Volume 1938 shows a variety and depth which would do credit to any other country in the world. Social and cultural anthropology has naturally loomed large in the field and the study of social institutions, arts, crafts, games, folklore and religion has attracted a large number of workers. Physical anthropology has also claimed a fair attention of the research workers but little energy and thought seem to have been devoted to the problems of racial biology, of human genetics, of relation between physique and nutrition. Little do we know of the conditions of growth and normal stature of various types and groups of people that inhabit this ancient and vast land. There is no adequate data available as to the normal build of Indians in various parts of the country, and there is no reliable evidence to indicate whether we in India are advancing towards becoming an A_1 nation or downgrading to a C_3 type.

Small beginnings have been already made and studies by Dr. S. L. Bhatia of the lung capacities of students in Bombay, and of the vital capacities of students in Bengal by A. N. Chatterjee and of the vital capacities of the Malayalee, Tamil and Telugu women in South India are all important beginnings. The work done at the Nutritional Research Institute at Coonoor by MacCarrison and his brilliant successor Aykroyd has opened a new field covering the relations between physique and diet, between diet and capacity for work and between diet and susceptibility to disease. It bids fair to excellent results as it has opened the eyes of the intelligent public to the defects resulting from malnutrition.

18. An enquiry among the famine influx population of Calcutta.

J. K. BOSE, Calcutta.

Hundreds of families came to Calcutta from neighbouring districts for want of food during the months of July, August and September. An investigation among one hundred families was made near about the Ballygunge Station within the jurisdiction of the Calcutta Municipality. Most of these people came from 24-Parganas. Some of them have lost their houses and other belongings due to flood. They may be classified into three groups, viz. landless labourers, floating population of the village, and cultivators. In the course of movement they have lost their relatives and children from disease and for want of proper nourishment.

19. The *Kumbham* ceremony of the Kurichiyas of Wynaad.

A. AIYAPPAN, Madras.

For the annual *tera* festival in some of the temples of Wynaad each Kurichiya joint family makes an offering of palm wine stored in one of the middle internodes of a long green bamboo pole. The rituals connected with this offering are briefly described in this paper. (16 mm. cinematographic films taken of the ceremonial will also be shown). The paper attempts to show how the unsympathetic administration of excise regulations has handicapped the religious and economic life of the Kurichiyas.

20. Some aspects of crime culture in the U.P.

D. N. Majumdar, Lucknow.

There are over 1,400,000 men, women and children in the United Provinces alone who are tied to crime from birth and by profession, these belonging to all religions, particularly Hindus and Mahomedans, the former contributing the major proportion of the criminal tribes in northern India. There are no less than 50 tribes who live a life of crime and are under police surveillance as required by the Criminal Tribes Act. In one year (1938), property worth Rs.30 lakhs was stolen by them in the U.P. There were 34,000 cases of burglary and 3,400 cases of cattle lifting in that year alone, committed by members of these tribes. They have also the largest representation in the jail population of the Province; 40,000 members of the tribes are registered criminals in the U.P.; 21% of the inmates of the Benares State prisons come from the criminal tribes. A brief review of the various aspects of crime culture, crime insurance and crime control is given in the paper.

21. Santal migrations.

K. P. Chattopadhyay, Calcutta.

The writer discusses the evidence of traditions as collected by Dalton, Bodding and by himself. The theories of Skrefsrud, Waddell and others are criticised. Relying on the geographical evidence, the author points out that the Santals probably came from the Kaimur range, through the Champa Pass and other neighbouring Passes into the Chotanagpur plateau, before their dispersal further east.

SECTION OF MEDICAL AND VETERINARY SCIENCES

President:—K. V. KRISHNAN, M.B.B.S., M.R.C.P., D.B., D.Sc., F.N.I.

Bacteriology

1. Bacterial standards for ice-cream.

K. V. KRISHNAN, S. C. GHOSAL *and* R. BANERJEE, Calcutta.

Within the last twelve months a few hundred samples of ice-cream, collected from various sources in and around Calcutta, have been examined bacteriologically. The interpretation of the results obtained lead to the necessity for prescribing standards. At present there are no standards for ice-cream in this country and no laws prohibiting the sale of ice-cream of bad quality. The standards recommended by advanced countries like U.S.A. and Great Britain are regarded as too rigid and unattainable even by the best manufacturing firms. On the basis of the experience gained, the authors feel that the following standards would be suitable for India.

Class A	..	No coliform in less than 0·1 c.c.
		Total count not more than 100,000 per c.c.
Class B	..	No coliform in less than 0·01 c.c.
		Total count not more than 200,000 per c.c.

Both can be passed for consumption, but those falling below Class B should be prevented from being sold. This is particularly important in a country like India where intestinal diseases are widely prevalent and the control of these is a major responsibility of the Public Health Departments.

2. Fate of *Vi* antigen of *Bact. typhosus* in natural water.

S. C. GHOSAL, Calcutta.

It is well known that *Vi* antigen in *Bact. typhosus* rapidly disappears when grown in artificial medium unless special precautions are taken. The fate of this antigen is not known when the organism gets on to water, sewage, etc. in the environment. An attempt was made to elucidate this point. Therefore freshly isolated strains of pure *V* form and *V·W* forms of *Bact. typhosus* were added to different types of water and isolated from these after varying intervals of time and tested serologically. It was found that *Vi* form did not disseminate but *V·W* form showed variation as was to be expected.

3. Method of determining the temperature inside autoclaves during sterilization.

K. V. KRISHNAN, S. C. GHOSAL *and* E. K. NARAYANAN, Calcutta.

When a large volume of material is being sterilized, as in blood banks, one has to make sure that the sterilization is effected perfectly. In the course of our routine work it was found that the pressure-gauges of autoclaves do not always indicate the inside temperature accurately. The actual temperature prevailing inside the different articles in an autoclave during sterilization was determined in a number of instances, in

different ways. Among the methods tried the use of thermocouples gave the best results. Description of the method of using these is given. The nature of variation in temperature inside autoclaves is discussed.

4. Types of C. diphtheriae prevalent in Calcutta.

S. C. GHOSAL, Calcutta.

Since 1935 a few hundreds of throat swabs of diphtheria patients have been examined. The type of organism isolated has been determined and an attempt made to correlate the severity of the case with the type isolated. It has been found that *gravis* and *intermediate* types are relatively few in Calcutta and that the predominating type is *mitis*. The *mitis* type found in Calcutta causes slightly more severe disease than the *mitis* type in England.

5. Voges Proskauer test.

R. BANERJEE, Calcutta.

In the Voges Proskauer test prolonged incubation at 37°C. of the organism for more than two days in glucose phosphate medium is liable to make a positive result into a negative one. A short period of incubation in this medium for 24 hours is quite sufficient if the Barrit's method of testing is employed.

Even under optimum conditions the original V.P. test is never so satisfactory as Barrit's test. If one wants to do V.P. or Barrit's test after the usual three days' incubation instead of after one day's incubation then glucose peptone of *p*H 8 should be used in place of glucose phosphate medium.

6. Cholera epidemic in Bihar caused by the 'Ogawa' type of *V. cholerae.*

S. K. CHATTERJEE *and* S. AHMAD, Patna.

It is generally believed that wide-spread epidemics of cholera are caused by the 'Inaba' strains of *V. cholerae* and that the 'Ogawa' strains are associated with sporadic cases and mild outbreaks. Venkatraman and Pandit have shown that severe epidemics of cholera in South India were caused by 'Ogawa' strains. The paper shows that widespread epidemic of cholera could be caused by 'Ogawa' strains, but in this series the death rate in the epidemic was low. Choleraphage has been in extensive use in the province for a pretty long time. There is no sufficient data to conclude that the classical vibrios have undergone modification due to phage action, but it is suggested that it may be so.

7. Treatment of cholera by atebrin.

G. PANJA, Calcutta.

Atebrin in a high dilution was found bacteriostatic and bactericidal to *V. cholerae in vitro.* The drug was tried by mouth, one tablet every 15 to 30 minutes until 4 to 6 doses, in 20 cases of cholera and results were found very encouraging. Only one course of treatment was generally necessary and the drug was well tolerated and retained. The number and amount of salines necessary for injection were much less than in the control series. General condition as a rule improved fairly rapidly and free flow of urine was quickly established. The duration of the disease in all cases varied from 6 to 14 hours before atebrin was given but all cases recovered excepting one in a child of only one year's age. Although the patients were cured, still they were passing live vibrios in the stool from day to day as in the control series. The virulence and roughness of such vibrios were not tested.

Eight cases of cholera were tried with quinacrine (M. & B) but results were not so encouraging as with atebrin.

It is hoped that if further trials of atebrin are given in eatly cases of cholera, saline injection may not be necessary at all.

8. An advanced case of Johne's disease in a Bellary ewe.

S. V. Mudaliar, Madras.

Records of the incidence of Johne's disease in sheep have been very few compared with that of cattle. An advanced case of the disease was diagnosed in an ewe at the Livestock Research Station, Hosur, which did not react to the Johnin and Avian tuberculin tests. This animal was losing flesh and weight and developed a puffiness and oedema under the lower jaw which was prominent in the evening and disappeared the following morning. The animal had no diarrhoea and examination of faeces showed Johne's bacilli in large numbers. She was destroyed and the post-mortem lesions were quite characteristic of the disease. The lesions in the intestines particularly in the ileum, caecum and colon were very marked, similar to the condition in bovines and a record of this in sheep is made for the first time now, since the findings of the previous authors were distinctly against this. A photograph of this lesion together with inflamed mesenteric glands and microphotographs of sections of the ileum and mesenteric lymphatic glands are included.

9. A pathogenic organism isolated from stool of a case of hill diarrhoea.

G. Panja, Calcutta.

The organism was isolated on my new D.E.C. medium on two successive days. It is a non-motile lactose-nonfermenter, produces acid and gas in dextrose, mannitol and maltose and bears no antigenic relationship with the dysentery bacilli excepting a little with Y and another gas-producing organism isolated locally from an acute bacillary dysentery case. It is highly toxic to rabbits and mice. A mild form of diarrhoea was reproduced by feeding 4 volunteers with large doses of the organism and the organism was recovered from their stools.

10. A simple test for differentiating Anthrax bacillus from subtilis group of bacilli.

G. Panja, Calcutta.

If *Bacillus anthracis* is grown in nutrient broth or peptone water for 18—20 hours and a solution (1 in 5,000) of brilliant green (Grubler & Co.) in distilled water is added so as to render the culture fluid green-coloured and then the culture is incubated at 37°C. the green colour persists and all the organisms are killed in 1 to 2 hours. Members of the subtilis group (including *B. subtilis*, *B. mycoides*, etc.) similarly treated are not killed, not only in an hour but also sometimes for days. Moreover, the green colour is partly or completely discharged in a few hours or the next day. Persistence of the original green colour is always seen in the case of anthrax bacilli. A more precise test can be done by growing the organisms in 9 c.c. of nutrient broth or peptone water of pH 7·0 and adding to it, 1 c.c. of 1/5000 dilution of the dye in sterile distilled water so as to make the final dilution 1 in 50,000. Spores of anthrax bacilli alone are also killed by the dye within 24 hours. It is interesting to note that a mixture of anthrax bacilli and the dye injected into a guinea-pig is either non-lethal to the animal or delays its death. Similarly if the dye is injected locally after a lethal dose, life of the animal is prolonged.

Injection of the dye is suggested in cases of malignant pustule in and around the lesion.

11. Aetiology of ulcus tropicum.

G. Panja, Calcutta.

An epidemic of ulcus tropicum (Naga sore) is reported in Calcutta. This is the first time that cases of Naga sore are met with in the city. Fusiform bacilli are always associated with the lesion. In some cases, fusiform bacilli only have been found in abundance and no other organisms were seen by culture and smear examination. These bacilli have been successfully cultured on blood agar slopes in an anaerobic condition set up by pyrogallic acid and caustic potash. By intradermal or subcutaneous injection of the bacilli alone, no typical sore with presence of fusiform bacili in smears has been reproduced. But when pus-showing fusiform bacilli alone is injected or applied to an ordinary ulcer, typical sore is often reproduced. The fusiform bacillus is an extremely delicate organism and failure to reproduce sores with pure cultures of the organism is probably due to the non-production of requisite O-R potential or some other factor. No virus has been demonstrated in the sores; filtrate of pus is harmless and no immunity has been found.

Avitaminosis does not appear to play an essential part in the causation of the disease.

12. The inhibition of other bacteria by *Pseudomonas pyocyaneus.*

C. O. Karunakaran *and* C. Gopalan Nair, Trivandrum.

In blood cultures received from cases of typhoid fever the presence of *Pseudomonas pyocyaneus* was found to inhibit the growth of *Bacterium typhosum* and interfere with its isolation in a pure form. An investigation was therefore carried out to find out the factors responsible for this inhibition and in addition to *Bacterium typhosum*, *Bacterium coli* and *Staphylococcus aureus* were also included in the experiments.

If *Bacterium typhosum*, *Bacterium coli* and *Staphylococcus aureus* were allowed to grow in broth cultures together with *Pseudomonas pyocyaneus*, *Bacterium typhosum* and *Bacterium coli* gradually died out in the course of one to two weeks, while *Staphylococcus arueus* ceased to live for half of that time. The date of disappearance of these organisms depended in general on the intensity of pigment production. If pigment production was poor, the organisms continued to live as in ordinary broth cultures.

While the presence of *Bacterium typhosum*, could be demonstrated by sub-cultures in broth and by sugar tests, the chances of isolation in a pure culture by plating out on agar or on a differential medium like the Mac Conkey agar appeared to be very meagre, even in the case of 24-hour old cultures.

The Bacteria-free filtrates of five-day old broth culture of *Pseudomonas pyocyaneus*, if added to nutrient broth in concentrations of over 20%, had a decided inhibitory action on the growth of these organisms. The degree of inhibition depended upon the concentration of the filtrate in the culture. Not only growth was stopped but the turbidity produced by the initial growth disappeared, suggesting lytic action. Pyocyanin-free filtrate had almost the same effect on *Bacterium typhosum*, but the other organisms continued to live for longer periods.

Crystalline pyocyanin obtained from a five-day old culture had no inhibitory action when added to broth in the concentration in which it occurred in the cultures which appeared to inhibit growth. But very high concentrations of the pure pigment had a lethal effect.

The inhibitory action of Pseudomonas pyocyaneus on the organisms tested has been proved. While the pigment has a decided lethal action, it appears that some other product resulting from the growth of Pseudomonas pyocyaneus also plays a rôle in this and that factor, probably enzymes like pyocyanase, has a lytic action on other bacteria. It appears

that both the pigment and this factor have a complementary action and that the production of the pigment and that of the lytic enzyme are closely associated.

Transplants on agar slopes of blood cultures might show such intense pigmentation when *Pseudomonas pyocyaneus* occurs in association with *Bacterium typhosum* that the presence of the latter may be overlooked unless sugar test be done. Isolation from plate cultures will also be difficult because not less than 90% of the single colonies picked up might prove to be either pure pyocyaneus or its mixture with Bacterium typhosum. The difficulty of isolating other organisms in pure cultures on plating might be due to the *Pseudomonas pyocyaneus* sticking to these organisms by the glutinous product of its growth.

13. Cystine hydrochloride broth for black-quarter vaccine.

V. R. Rajagopalan, Mukteswar.

Cysteine hydrochloride can be used for anaerobiosis for the growth of *Cl. chauvoei* for the routine manufacture of black-quarter vaccine. The medium is made up by adding 1% peptone, 0·5% sodium chloride and 0·05% cysteine hydrochloride to meat extract, which is then adjusted to a *p*H of 6·0 to 6·4 and sterilized at 120°C. for half an hour. The medium should be seeded on the same day as soon as it has cooled down to body temperature. The inoculum should be 0·5 to 1% of an 18–24 hour culture in the same medium or in meat medium.

It has been shown that an anaculture made from two days' growth is as good as one made from fourteen days' growth. Filtrates obtained from anaculture of *Cl. chauvoei* has no protective properties. There is an indication that a combined chauvoei-septique anaculture may be a better immunizing agent as the immunity established is then both anti-bacterial and anti-toxic.

Serology

14. Biological testing of transfusion material.

K. V. Krishnan, B. Mukerji *and* N. K. Dutt, Calcutta.

A method of testing biologically serum and plasma processed in blood banks has been elaborated. Cats weighing 2·5 to 3·5 kilos are used as experimental animals. They are brought to a state of haemorrhagic shock and then transfused with the material to be tested. Reactions, if any, are noted as well as changes in blood pressure. On the basis of the results obtained the quality of the product is classified as 1, 2 or 3. Only 1 and 2 are recommended for use in humans. From the experience gained from over 200 experiments, it appears that the test is useful not only for determining the quality but also for improving the technique of preparation.

15. Hydrolyzed proteins as transfusion material.

K. V. Krishnan *and* E. K. Narayanan, Calcutta.

In the treatment of hypoproteinaemia intravenous transfusion of a mixture of amino acids and peptides produced by the hydrolysis of proteins has been found efficacious. If the mixture contains the essential amino acids in proper proportion and if sufficient carbohydrates are also provided to supply the calorific need of the body, the whole of the transfused nitrogen appears to be built up into serum proteins within a few hours. Enzymic hydrolysates of biologically complete proteins as well as acid hydrolysates with supplements of tryptophane and cystine are satisfactory. The hydrolysis has to be conducted as near to the amino acid

stage as possible and the preparation tested immunologically to ensure freedom from anaphylactic properties. Such a preparation has been produced and the trials so far conducted both in animals and in man (in starvation cases) have given encouraging results. This preparation appears to have a pronounced effect on cases of oedema due to starvation —the oedema disappearing in most cases within 24 to 48 hours.

16. Albumin as transfusion material.

K. V. Krishnan, E. K. Narayanan *and* J. C. Gupta, Calcutta.

In many war injuries, such as, shock, burns and haemorrhage, the immediate concern is the maintenance of blood volume and blood pressure of the individual. These can be achieved by the transfusion of solutions of (1) crystalloids like saline and glucose-saline, or (2) colloids like whole blood, plasma, serum, purified proteins (preferably of the same species or of others giving as little immunological response as possible) or vegetable colloids such as gums and pectins. In the case of crystalloids and to a lesser extent, vegetable colloids, the transfused fluid is not retained in the circulation but escapes into regions of greater osmotic tension outside the circulation, viz. the tissues or get out via the kidneys, and the effect therefore is transient. But if protein solutions are transfused, especially in high concentration sufficient to withstand the colloidal osmotic pull from the tissues or preferably to overcome and reverse the direction of the flow of fluid, the effect would be marvellous and lasting. Purified albumin, unlike any other substance till now known, has the unique advantage of being capable of administration in very high concentrations. It can be given as a 25% solution and every gram of the protein injected will be capable of drawing 15 c.c. of fluid from the tissues into the circulation. Blood volume and blood pressure will thus be quickly brought to normal and it is on account of this that albumin therapy is now being attempted.

A few samples of human albumin were prepared and tried on cats in a state of experimental haemorrhagic shock. The results were encouraging. It would be worth while preparing albumin on mass scale for use in human cases, both from human and animal sources. The results of experiments so far done are presented.

17. Chemical method of obtaining dry blood proteins for transfusion purposes.

K. V. Krishnan *and* E. K. Narayanan, Calcutta.

As an alternative to the physical methods of obtaining serum proteins in dry form for transfusion purposes some chemical methods were developed by making use of an observation of Hardy and Gardiner (1910) that the temperature coefficient of denaturation of proteins by alcohol or acetone is of the order of 600 per 10°C. This method, for which the name '*Hardyization*' has now been given, consists in adding serum at0°C. to a large volume of alcohol or acetone kept at −10°C. The precipitated blood proteins are separated suitably at a temperature below −5°C. and washed twice again with fresh cold alcohol or acetone and then with ether till no more alcohol or acetone can be detected. The ether-moist protein is rapidly dried in a current of dry air and then in a vacuum desiccator. The product is a pearl white powder easily soluble in cold water or normal saline. Experiments with sheep's blood proteins early in 1942, showed that the process did not denature the proteins. Transfusion of the product to a sheep was unattended by reactions. There was also no formation of precipitins as a result of the injection. Reports since received from Australia show that similar work is being done on a large scale and claims

are being made that '*Hardyized*' serum protein is free from certain pharmacological peculiarities met with in liquid serum and physically dried serum proteins. Dry proteins of human serum have also given satisfactory results in our hands.

18. Blood studies in protein deficiency.

NARAIN DAS KEHAR *and* V. V. S. MURTHI, Izatnagar.

In view of the deficiency of protein commonly met with in livestock in India and the lack of information on the clinical manifestation of this deficiency in the blood of domestic animals for diagnostic purposes, a systematic study was undertaken to see how the different blood components were affected when cattle were maintained on a low nitrogen ration for a considerably long period as compared with those on normal ration.

It has been observed that protein deficiency in cattle affects total white blood cells, cell volume, blood sugar, haemoglobin, total cholesterol, total protein, Euglobulin, total globulin and total non-protein nitrogen.

19. Factors which vitiate blood group determination.

C. O. KARUNAKARAN *and* C. GOPALAN NAIR, Trivandrum.

The technique of blood grouping adopted by the authors is a combination of the macroscopic test advocated by Taylor and the microscopic test commonly employed in blood grouping work.

Qualitative and quantitative differences which might occur from the use of defective sera and the necessity of using strong undiluted sera in apparently negative cases to detect weak reactions are pointed out.

Although it is generally believed that weak reactors might be A's, it appears likely that some weak B's also might be missed if the antiserum used is not potent enough.

The unaccountable character of many reported blood group distributions and the accidents which have followed after blood transfusions from apparently well-matched donors might be due to the use of defective typing sera or faulty technique in typing.

The necessity of standardization of tests for more comparable results is stressed.

20. Blood groups of communities in Travancore.

C. O. KARUNAKARAN *and* C. GOPALAN NAIR, Trivandrum.

Blood group distribution of 1,865 persons taken at random has been determined and discussed in a community-*war* basis and compared with group distribution of communities in other parts of India.

The technique followed is briefly described.

The two major Hindu communities, Nairs and Ezhavas show little significant variation in group distribution. Ezhavas, however, show a slight predominance of O over the other.

The distribution of groups is much the same as that of Hindus in Madras.

The Christians have a higher proportion of B's than Nairs and Ezhavas, and a lower proportion of A's.

The group distribution of Mohammedans show the highest proportion of B's, and the lowest proportion of AB's, being very similar to their coreligionists of Madras in this respect.

In view of the social restrictions among the Hindu it will be more useful, if in grouping them, information is collected on a communal basis.

21. Interfering organic substances in routine precipitin tests.

C. O. KARUNAKARAN *and* (MISS) VICTY VEDAKKAN, Trivandrum.

1. Non-specific reactions in medico-legal precipitin tests although small in number are of great significance in some cases.
2. The articles associated with stains which give non-specific reaction have been studied.
3. The leaves and woods of most of the common trees contain the non-specific factor. Although the saline extracts are generally acid they may also be neutral. Change of reaction does not affect its non-specific precipitating power.
4. The practice of betel chewing and the use of knives for cutting arecanut and other tannin-containing articles is perhaps responsible for the non-specific reaction occasionally shown by blood stain on clothes, earth and knives.
5. Some methods by which the non-specific factor can be removed without affecting the protein contents of the extract will be helpful in the investigation of these cases.

22. Precipitin test in the determination of the food preferences of mosquitoes.

C. O. KARUNAKARAN *and* M. A. U. MENON, Trivandrum.

1. Mosquitoes reared and fed on man in the laboratory, and maintained at room temperature (82° to 87°F.) were tested at intervals to find out the period during which evidence of blood could be detected.
2. The mosquito blood meal was extracted with 1 c.c. of saline and 3 c.c. of saline and a potent diagnostic serum was used for tests, undiluted.
3. The weight of an average meal of blood of *Stegomyia Vittatus* has been estimated.
4. Blood stains on filter paper, diluted to 1–1,000 was found to react with diagnostic sera like a serum dilution of about half the antigenic strength.
5. Mosquitoes collected within inhabited houses were tested using 1 c.c. and 3 c.c. of saline for extracting the blood meal, against pure anti-serum and antiserum dilutions made with the diluting fluid recommended by Rice and Barber (1939).
6. The chances of detection of positives are considerably reduced by diluting the blood meal with 3 c.c. of saline and also by diluting the anti-serum. Although the average weight of blood meal in a freshly engorged mosquito might indicate that dilution with 1 c.c. saline will give too high a concentration of the antigen to be considered specific, in practice this dilution does not appear to be unsafe for use while in most cases dilution with 3 c.c. will reduce the antigenic concentration to such a degree that positives are likely to be missed especially if diluted antiserum be used for the test.

Dilution of serum with saline failed to give satisfactory results.

23. The typhoid vaccine (T.A.B.) in the control of enteric fever.

C. O. KARUNAKARAN *and* P. K. SANKARA PILLAI, Trivandrum.

Enteric fever is one of the major public health problems of Travancore, as in most other parts of India. Till sanitary conditions are radically improved the main hope of control lies in extensive mass immunization with T.A.B. But the reaction caused by the vaccine stands against its general use.

Experiments were carried out by the authors to find out if the reaction can be reduced: (i) by purifying the bacterial cells, (ii) by allowing the vaccine to age, and (iii) by altering the dosage.

Injections were given to adults who never had enteric fever before and had not been inoculated with T.A.B. and the agglutinin content of the blood estimated before and after immunization.

It was found that purification of bacterial cells did not materially alter the reaction. Aging within the limits of the experiment (2–5 months) also produced no significant difference. But three inoculations with 0·1 c.c., 0·5 c.c. and 0·75 c.c. markedly reduced the reaction and caused higher rise in agglutinins.

Since the reaction following 0·1 c.c. is almost negligible, the tragedy of an aggravated attack, should the usual initial dose of 0·5 c.c. be injected in the incubation period, may be totally eliminated by this altered dosage.

Although all cases showed varying degrees of local and constitutional reaction the proportion of cases in which it was marked enough to keep the subject confined to bed for 24–48 hours was very small (2 in 34).

A high proportion of the subjects showed natural agglutinins to one or more of the organisms concerned, the level of agglutinins in some being significantly high. The agglutinin response following injections was more striking in cases having natural agglutinins. One of the subjects showed little agglutinin rise after two injections and even after a third dose the response was poor.

Protozoology

24. Studies on surra. II. Two autopsies. A horse and a dog dying of experimental infection with *Trypanosoma evansi*.

H. N. Ray, Mukteswar, *and* H. K. Lall, Lahore.

The post-mortem findings on the carcases of a horse and a dog are recorded in the paper. These animals succumbed to the experimental infection with *Trypanosoma evansi*. Hawking and Greenfield are of opinion that in acute cases of *Trypanosoma rhodesiense* (sleeping sickness) in man, the visceral lesions are much more harmful to the patient than those of nervous tissues. While we are inclined to confirm this view, we would like to raise the question as to whether the carbohydrate imbalance has any direct effect in the causation of such lesions. A study *in extenso* of the endocrine glands of cases of surra appears warranted, towards the elucidation of factors concerned with carbohydrate metabolism.

25. Studies on Surra. III. The problem of detecting surra in equines and bovines.

H. N. Ray *and* S. N. Sapre, Mukteswar.

Observations on the use of complement fixation test and nitric acid for detecting trypanosomiasis in equines and bovines have been recorded. Detection of 'carriers' during the off-surra season has been emphasized. Since these reactions are only group reactions it is suggested that in order to eliminate *T. theileri* infection in bovines cultural and biological tests should be resorted to.

26. Studies on fowl malaria (*Plasmodium gallinaceum*).

B. C. Basu, Izatnagar.

This is a highly fatal disease in fowls as observed in the experimental birds, only a few survive the infection. No relapse has occurred in the recovered birds. Birds once recovered from this infection have been found to develop solid immunity against further infection with this disease. Taking advantage of this observation, a method of prophylaxis against

this disease has been worked out by infecting the birds with the parasites (*P. gallinaceum*) of the disease and afterwards treating them with usual antimalarial drugs. Pure as well as cross-breeds of fowls (White leghorn; Rhode Island Red; Country; cross between White leghorn and country; cross between Rhode Island Red and country, and cross between White leghorn and Rhode Island Red) have been found to be susceptible to this infection. Arthropod transmission of the disease is under investigation.

27. Further studies on the rôle of protozoa in activated sludge.

S. C. PILLAI *and* V. SUBRAHMANYAN, Bangalore.

The rôle of *Epistylis* sp. in the flocculation sewage colloids, in the oxidation changes and in the conservation of nitrogen in activated sludge has already been reported.

Further studies have shown that the protozoa actually flourish in presence of large quantities of fresh faecal and other organic matter. Given sufficient supply of air, they digest and otherwise facilitate the oxidation of organic matter.

Insufficient supply of air inhibits the growth and active functioning of the protozoa; insufficient supply of fresh organic matter (as represented by raw sewage) and excessive supply of air is also unfavourable to them. In the former case, the protozoa get killed and the sludge gets filled with gas, so that the phenomenon of bulking is often observed. In the latter case, the protozoan cells begin to disintegrate and a black, burnt condition is observed. The black colour is due to an oxidase present in the protozoa.

The problem of dewatering activated sludge is closely linked with the physical condition of the protozoan cells which are slimy and hold large quantities of water.

28. A note on *Aegyptianella pullorum* infection in fowls in India.

B. C. BASU, Izatnagar.

Studies were made on *Aegyptianella pullorum*—a condition regarded as a disease entity in fowls, a strain of these parasites having been isolated from a fowl under experimentation in the Pathology and Bacteriology Section of the Imperial Veterinary Research Institute, Mukteswar in July 1940. The condition could be produced in healthy fowls by blood inoculation. Spleen, kidney, liver, lungs, brain and bone marrow also show the organisms during the acute phase, when they are seen in red blood corpuscles. This is neither a fatal nor an important disease. It has already been reported from Africa, eastern border of Mediterranean and Russia. In 1941, a few blood smears of fowls suspected to be suffering from Spirochaetosis were received from the V.I.O., Baroda. The slides showed no spirochaetes but contained bodies indistinguishable from *Aegyptianella pullorum*. The question therefore arises as to whether these bodies represent the so-called 'Balfour granules,' the existence of which as a stage in the development of *Spirochaeta anserina* was denied by the writer and his collaborators (1932). This question is under study.

Malariology

29. Malaria control at Izatnagar by antimosquito measures.

B. C. BASU, Izatnagar.

At Izatnagar (District Bareilly, U.P.) in four adjoining colonies (area about 3 sq. miles), namely, Imperial Veterinary Research Institute, O. and T. Railways, Central Jail and Indian Wood Products Co., attempts were made to control mosquito-breeding by weekly application of 'Paris green' and 'Malariol' in breeding places at different seasons of the year.

Mosquito nuisance has been considerably reduced. Pyrethrum-Kerosene mixture is sprayed once a week during malaria season in the quarters occupied by coolies and by inferior servants for killing adult mosquitoes and in other quarters as required. This is the second year of this work which has led to a considerable reduction of the cases of malaria in these four areas.

30. Some epidemiological features of malaria transmitted by *Anopheles fluviatilis* James.

D. K. Viswanathan, Bombay.

A. fluviatilis transmits malaria along the Western Ghats—Thana to Cape Comorin; Deccan and Mysore Plateau; the Eastern Ghats.

Very efficient vector; predominantly house rester by day; favours particular houses and particular corners. Enters houses for feeding soon after dark; is well-fed before mid-night. Principally anthropophilic.

Breeding-grounds: Rice-field channels; streams; terraced ravines; fallow rice-fields with seepage; *Kutcha* field wells. Grass-grown margins specially favoured. Channels in forests with dense cover often free.

Season: With high rainfall and undulant country, December to May, if perennial stream nearby; if not, October to January. With low rainfall August to November.

Parasites: *Falciparum*, *vivax* and *malariae* prevalent; last more common than elsewhere.

Population: Greatly decimated due to excess of deaths over births and of emmigration; check on cultivation due to unhealthiness and depradation by wild animals. Smaller-sized villages rapidly depopulated.

Vulnerability to control: Sparsity and house-resting habits favourable for spray killing. Anthropophilism and high carrying capacity unfavourable. Specific breeding grounds and their proximity to human habitations render anti-larval species sanitation feasible but extreme scattering of houses require large area to be tackled. Concentration of housing, siting and large-scale colonization would render control easy and economical and facilitate tapping the rich natural resources of the *fluviatilis*.

31. Indigenous drugs in the treatment of malaria.

C. O. Karunakaran *and* M. A. U. Menon, Trivandrum.

An investigation has been carried out into the efficacy of indigenous drugs in the treatment of malaria with a twin purpose, (i) to find out if there was any indigenous drug which could effectively replace quinine, and (ii) if there was none, to correct the mistaken impression created among the public by the followers of the indigenous systems that they had useful antimalarial drugs. A prize of Rs.1,000 was offered by the Travancore Medical Association for a drug which satisfied the conditions: (*a*) it should be non-toxic, (*b*) it must destroy parasites and cure clinical signs within ten days, (*c*) it should not contain quinine, atebrin and plasmoquin, (*d*) it should be cheaper than quinine. The offer was thrown open also to the followers of the homeopathic system. The investigation begun in 1935 under the auspices of the Travancore Medical Association has recently been taken up by the Research Department of the Travancore University.

Fifteen drugs, including tincture of Dita bark (*Alstonia scolaris*) has been tried in cases, treatment being conducted in some cases under the direct supervision of the physicians who were supplying the medicine.

Physicians of long standing and good repute did not accept as malaria. cases in which the spleen was enlarged enough to be readily felt, considering such cases as some splenic disease, but not malaria, and had to be given cases in which splenic enlargement was not pronounced.

A few of the drugs offered for trial, but not tried, contained small amounts of quinine. Some contained arsenic. Some, which were free from inorganic poisons, contained organic poisons which were dangerous cardiac depressants.

No drug had parasiticidal action.

Temporary clinical improvement which occurred in stray cases could easily be explained on the basis of natural improvement which occurs in some cases.

The genuine notion entertained by some physicians about the anti-malarial potency of their preparations appears to be either the result of mistaken diagnosis of cases treated as malaria or due to the acceptance of temporary improvement of clinical manifestations as cure. Careful examination of blood before and after treatment will be helpful in correcting this error; but it appears that the practitioners of indigenous systems attach little significance to the presence of parasites in the blood.

Plague

32. Rats of Calcutta city: investigated from a point of view of epidemiology of plague.

S. Raghavender Rao, Hyderabad (Deccan).

A rat survey of Calcutta city was carried out during the periods January 1936 to September 1936 and October 1938 to December 1938. Altogether 3,961 rodents were examined and of these 557 (9·1%) belonged to the species *Rattus rattus*, 848 (13·9%) to *Rattus norvegicus*, 1,164 (19·0%) to *Gunomys varius*, 1,159 (19·0%) to *Mus musculus* and the rest, 218 (3·9%), to other species. These results have been compared with those obtained in 1906-07 by Hossack, who carried out a similar survey during the period when plague was prevalent in an epidemic form in Calcutta city. Resistance to plague infection of these different local species of rats has been estimated by standardized methods and this has been discussed in relationship to the long and short term periodicity of plague. *Rattus norvegicus* was found to be the most resistant and *Gunomys varius* to be highly susceptible to plague infection. Opinion has been expressed that the establishment of symbiosis between the organism, *Past. pestis*, and its host (prevalent species of the rodents) is responsible for the ultimate disappearance of plague in an epidemic form from any place, where all other conditions are still suitable for the prevalence of the disease.

33. Plague in the coastal towns of Travancore.

C. O. Karunakaran *and* M. A. U. Menon, Trivandrum.

Plague is not endemic in Travancore. Two regions which are topographically and climatically different from each other have been subject to sporadic outbreaks of plague. These are the highland area in the north-east adjoining the Cumbum valley and the coastal area in the west. An investigation has been made into the epidemiology of the outbreaks which have so far occurred in the coastal towns of Alleppey and Quilon.

The main conclusions are:—

(i) Plague is not endemic in the coastal area of Travancore.

(ii) In all epidemics the source of infection has been Mattancherry (Cochin State) with which the coastal towns are in constant commercial intercourse.

(iii) The predominant species of rat in the affected towns is ***Rattus rattus*** (white-bellied variety).

(iv) The chief species of rat-fleas prevalent are *Xenopsylla cheopis*, *X. braziliensis* and *X. astia*.

(v) *X. astia* is the indigènous flea, being prevalent in bazaar as well as the residential premises of the towns in considerable numbers.

(vi) *X. cheopis* and *X. braziliensis* occur only in the bazaar areas and their concentration is highest in grain godowns. This indicates that these two species are not indigenous to this country but is constantly being introduced here through imported grain.

(vii) *X. cheopis* and *X. braziliensis* exhibit a marked tendency to persist in the zones which they have affected but very little to spread to other parts. This may either be due to restricted rat movement or the unfavourable conditions prevailing in the other parts of the towns.

(viii) The foci of epizootics and epidemics have been mostly the *cheopis* infested zones or their immediate vicinity.

(ix) There is no striking seasonal fluctuation in *cheopis* index; but *astia* and *braziliensis* indices tend to increase during the rainy season (June to November).

(x) The high humidity which prevails throughout the year in the sea-board is favourable to plague transmission. Meteorological conditions become most favourable during the rainy season when the mean temperature is comparatively low (85°F.) and the relative humidity high (often over 80%).

(xi) A most interesting feature of the coastal epidemics is the paucity of human attacks. The scarcity and restricted distribution of *X. cheopis* appears to be the main reason for this.

(xii) The limited distribution of *X. cheopis* is indeed advantageous in so far as anti-plague measures are concerned. It is possible to ward off plague by concentrating the measures, whether temporary or permanent, on the *cheopis* infested spots.

Helminthology

34. Immature forms of *Cotylophoron cotylophorum*, causing fatal enteritis in goats.

S. V. Mudaliar, Madras.

An outbreak of amphistomiasis in goats caused by immature forms of amphistomes, identified to be *Cotylophoron cotylophorum*, was met with in the Madras 'Pinjarapole'. Out of a herd of 40 goats, 19 succumbed to the disease. The symptoms included general weakness, suspended feeding, depression, oedema of subcutaneous tissues, diarrhoea, severe anaemia and death within five or six days. Diagnosis was very difficult during the life of the animal. A post-mortem examination on one of the carcases revealed intense enteritis with oedematous thickening of the duodenum and pyloric end of the abomasum and both these areas were studded over with immature amphistomes. An examination of the drinking-water source which was used by those goats revealed the presence of the fresh-water snail, *Indoplanorbis exustus*, among others. This *Indoplanorbis exustus* was found to discharge *Cercariae Indicae XXVI*, Sewell, 1922, and it is just possible that these are the larval forms of the immature flukes met with. Further work on the determination of the cercarial fauna of the locality had to be postponed to a more propitious season, since the snails were dying off due to the tank getting dry.

35. Some observations on the life-history of *Varestrongylus pneumonicus* (Bhalerao, 1932).

G. D. Bhalerao *and* B. N. Kapoor, Izatnagar.

Attempts were first made to determine whether the life-history is direct. Cultures of eggs and the first-stage larvae were kept in various media for 80 days but these larvae failed to undergo any further change of structure. These observations led to the conclusion that some intermediate host must be intercalated in the life-cycle of this worm. The commonest land mollusc *Macrochlamys cassida* and the slug *Girasia* sp. at Mukteswar were exposed to the infection of the first-stage larvae. These reached the infective stage in the mantle of the land mollusc in 24 hours, the slug being refractory to the ravages of the larvae. Compared with the first-stage larvae, the infective larvae were more active, had a well-developed oesophagus, oesophageal bulb with a trident, a well-developed intestine and an anus. The buccal capsule was wider and the tail was simple: the tail appendage of the first-stage larva having disappeared altogether. The molluscs thus infected were fed to kids and the results of this part of the experiment are awaited.

36. Some remarks on the identity of immature amphistomes causing diarrhoea in domestic animals in India.

G. D. Bhalerao, Izatnagar.

The condition known as immature amphistomiasis occurs throughout the whole of India. It affects goats, sheep and also cattle and invariably proves fatal. The question of the identity of the parasite or parasites causing this condition does not, however, appear to have been yet settled. Some attribute it to the immature forms of *Paramphistomum cervi*, while others do so to those of the species *Cotylophoron cotylophorum*. The writer has been interested in this problem for the last twelve years and had an opportunity to examine specimens collected in the United Provinces, Sind, Bihar, Assam and Madras. As a result of this study it has been found that different species of the genus *Cotylophoron* may cause this condition in different localities in this country. So far five species of this genus have been recorded from India.

37. A study of the life-history of *Dicrocoelium dendriticum*—the small liver-fluke of Indian ruminants.

H. D. Srivastava, Izatnagar.

There are three species of liver-flukes infecting ruminants in India. Two of these belong to the genus *Fasciola*—*F. gigantica* and *F. hepatica*—and the third is a small liver-fluke, *Dicrocoelium dendriticum*, parasitic in the bile ducts of sheep, goats, cattle and buffaloes.

The geographical distribution of *Dicrocoelium dendriticum* is restricted to the hilly tracts and the infection with this parasite is usually very heavy. Work on the life-history of this worm was commenced by me at Mukteswar in 1935 and, but for a few details, was completed by 1937. In the life-cycles of most digenetic trematodes an aquatic snail serves as the first intermediate host. The eggs hatch and the miracidia are free-swimming. The cercariae are also usually free-swimming and either encyst on vegetation or in or on intermediate host or penetrate into the intermediate or the final host. In the case of this small liver-fluke, however, it has been found that the eggs, with fully developed miracidia in them, hatch only after they have been ingested by the intermediate host. Fully developed miracidia remain viable inside the eggs for weeks without hatching. The intermediate snail is a land-snail which is fairly common in most of the hilly tracts, specially during and after rains. The cercaria

is also not free-swimming. The cercariae are discharged from the pulmonary chamber of the intermediate host in multiple cysts containing large numbers of them entangled in masses of mucus which the snail leaves behind as it glides along. Ruminants acquire infection by the ingestion of these multiple cysts deposited on vegetation.

38. A study of the life-history of *Paramphistomum explanatum* of bovines in India.

H. D. Srivastava, Izatnagar.

This trematode occurs in the bile ducts of cattle and buffaloes. Often the infestation is very heavy with the result that the bile ducts are literally choked. The walls of the ducts become thickly studded with prominent cylindrical papillae which are the seats of attachment of the amphistomes. The life-cycle of this parasite has been elucidated and it has been experimentally established that *Indoplanorbia exustus* serves as the intermediate host. Further work is in progress to find out if some other species of freshwater snails can also act as intermediate hosts in the life-cycle of this parasite.

39. A study of the life-history of *Gastrothylax crumenifer* of Indian ruminants.

H. D. Srivastava, Izatnagar.

Gastrothylax crumenifer is the commonest amphistome, parasitic in the adult stage in the rumen of sheep, goats, cattle and buffaloes in Northern India. In heavy infections several thousand specimens of this worm may be present in a single host. In a series of preliminary experiments it has been found out that *Indoplanorbis exustus* acts as the intermediate host in the life-cycle of this parasite. Laboratory-raised, clean specimens of some other species of aquatic snails have been subjected to infection with miracidia obtained from the incubated eggs of identified worms to find out if more than one species of snail can serve as the intermediate host. After the full details of the life-cycle of this parasite have been worked out, investigations into the pathogenicity, treatment and control of this trematode will be undertaken.

40. The intermediate host of *Fasciola hepatica* in India.

H. D. Srivastava, Izatnagar.

As a result of preliminary experiments it has been found that two species of *Limnaea*—*L. acuminata* and *L. luteola*—can serve as the intermediate hosts of this liver-fluke of ruminants in India. Laboratory-raised and parasite-free specimens of these species of snails were infected with miracidia obtained from incubated eggs of identified specimens of this parasite. Subsequent examinations of these snails revealed the presence in them of the different larval stages, including cercariae, of this parasite.

41. A new intermediate host of *Fasciola gigantica* of Indian ruminants.

H. D. Srivastava, Izatnagar.

This is the commonest liver-fluke infecting ruminants throughout the country. It has been experimentally found that, besides *Limnaea acuminata*, *L. luteola* can act as the intermediate host of this parasite. A comparative study of the morphology and anatomy of the larval stages of *Fasciola hepatica* and *F. gigantica* has also been made.

42. A strongyle nematode infecting the liver of Indian cattle.

H. D. Srivastava, Izatnagar.

Apart from the larvae of certain roundworms, which pass through the liver during their wanderings in the bodies of their hosts and then leave quickly for their seat of predilection, no adult strongyle nematode has been known to occur in the liver of bovines. In this paper is described an interesting strongyle nematode which has been found to occur, in the adult stage, in the liver of hill bulls at Mukteswar. The worms are very small and slender and the infection is rare and light. This is the first record in literature of the occurrence of an adult strongyle worm in the liver of bovines.

Nutrition

43. Animal husbandry in relation to war.

M. R. Mahajan, Ajmer.

In this paper attention is drawn to the very great importance animal husbandry is playing in the war. All recent researches on the subject have been yoked to effect the increased production of animal products all over the world to meet the demand for highly nutritive and essential food factors, such as milk and eggs, etc., and to better equip the men in the front lines with goods manufactured from such raw products as wool, hides and skins. India's economy and the prosperity of its countryside which is based on cattle, are receiving due share of importance in the increase of production and exploitation to the full of its wealth of livestock.

44. The vitamin A potency of some green fodders.

K. C. Sen, Izatnagar.

The bio-assay of the vitamin A potency of several green fodder plants has been made and it has been found that the amount of carotene determined by the alkali digestion method agrees well with the amount determined biologically using β-carotene as the standard.

45. Deficiency diseases in a famine area in Travancore.

C. O. Karunakaran, Trivandrum.

1. An investigation was carried out into a localized famine which occurred among the coir workers of Travancore in 1940 and 1941. The famine resulted from unemployment and not from food shortage.

2. A diet survey of the affected group and families of the same strata, but not affected by the famine, showed that normally their diet was qualitatively and quantitatively insufficient and that the famine had but 'pulled the trigger'.

3. Increased morbidity and mortality from oedema was its chief manifestation. Anaemia of varying grades was general among the affected population. Vitamin A deficiency and a few cases deficiency of vitamin B complex were seen. There were no cases attributable to the deficiency of vitamin B_1 or C. Glossitis was absent among children who had fish twice or thrice a week, but was noticed among the vegetarian group.

4. Gross cases of anaemia showed hyperinfestation with hookworm. Malnutrition was also associated with an increased infestation by ectoparasites, chiefly, *Sarcoptes scabeii*.

5. Famine oedema was found more amenable to treatment when protein-rich foods like eggs and milk were given together with vitamin A.

6. Shark liver oil was more beneficial and more easily tolerated by children than the red palm oil; and green gram was more helpful than an equal quantity of Ragi, probably due to its increased protein content.

7. In centres where the normal diet is insufficient, particularly in protein, one of the chief manifestations of famine might be oedema due to protein deficiency.

46. Influence of milk powder on fluorine intoxication in rats.

S. C. Pillai, R. Rajagopalan *and* N. N. De, Bangalore.

In view of the general observation that the incidence and severity of fluorine intoxication has a definite relation to the nutritional status of the communities, a series of experiments was carried out with young albino rats in order to study the gross effects of certain types of diets, whether any one or more of them could eliminate the symptoms of fluorosis. The animals, when fed on an adequate diet with liberal supplements of whole milk powder (1 to 2 grams of 'Klim' per day) along with water containing sodium fluoride (10 parts per hundred thousand, used both for mixing the diet and for drinking), did not develop any perceptible symptom of fluorosis, excepting mottled enamel which was noticeable after some days. The animals were quite healthy and the X-ray picture of their bone system was practically identical with that of animals receiving no fluoride. On the other hand, animals receiving a predominantly starchy diet with supplements of egg or fish powder (1-2 grams of fresh egg, about 25% of this weight represents the dry weight of egg used or 1 to 2 grams of bone-free fish powder prepared from a local variety of fish '*Karva*') quickly developed all the symptoms of fluorosis including the mottled condition. The animals developed stiffened and cramped limbs with occasional bleeding of the nose in two to three weeks, and some died shortly afterwards. Addition of bone powder (0·5 gram per rat per day) to the diets of the rats suffering from fluorine intoxication, however, brought about considerable improvement in their general condition and growth.

Comparative analyses of the diets employed showed that both the whole milk and the bone meal diets provided at least six times the amount of both calcium and phosphorus as the others. The associated proteins may also have been of use.

The above observations, though essentially of a preliminary character, serve to show that though mottled enamel is not ordinarily preventable, fluorosis of the bone can be controlled through provision of diets naturally rich in combined calcium and possibly phosphorus. The practical method of control and cure of the disease in man and farm animals are still awaiting solution, but appear to be within easy reach.

47. Disappearance of the mottled condition of the teeth in rats on changing over to fluoride-free water.

S. C. Pillai, R. Rajagopalan *and* N. N. De, Bangalore.

In a previous communication (Pillai, *Ind. Med. Gaz.*, 1942, 77, 19) it was reported that in the case of rats the symptoms of mottled enamel disappeared almost completely on changing over to fluoride-free water. With a view to studying this reversible type of mottled enamel in rats, further systematic experiments were carried out. In the earlier studies natural water containing fluoride (4-5 p.p.m.) was used for the experimental albino rats; in the present experiments distilled water containing 10 parts per million of sodium fluoride was employed. As the symptoms of mottled enamel developed in the experimental animals (after a month), they were changed over to fluoride-free water, and

observations on them were made. While considerable improvement of the mottled condition due to the change of water was observed by the end of a month, the symptoms disappeared almost completely by the end of two months. The exact mechanism of the disappearance of the mottled symptoms under these conditions is being investigated.

48. A diet survey of families in Trivandrum.

C. O. Karunakaran *and* R. Mukundan, Trivandrum.

A diet survey of 145 families in the city of Travandrum (Travancore), belonging to different economic groups, was carried out in January and February, 1941, and a third of these families was resurveyed six months later. At the time of the first survey there was little food scarcity. The second survey was done when prices had begun to rise.

The proximate principles and calorie value of the diets as well as average intake of milk and milk-products, leafy vegetables and fruits have been estimated.

It is found that the diets of families with a monthly income of Rs.20 and under were qualitatively and quantitatively insufficient. Families with a monthly income of Rs.20 to 50 had a diet which was on the borderland of sufficiency and with larger incomes the diets were better.

The intake of leafy vegetables was poor in all the groups.

In the groups with a minimum monthly income of Rs.100, the intake of milk and milk-products were found satisfactory. It was found to fall with the fall in income and in the case of the lower groups it was negligible.

The resurvey showed that owing to the rise in prices the diets of all the groups had deteriorated.

49. Tapioca—a study of local varieties.

R. Mukundan, Trivandrum.

Tapioca (*Manihot utilissima*) is one of the most important food crops of Travancore, being cultivated on more than six lakhs of acres. Normally the food of the poor and the fodder for cattle, the war has shown its great possibilities as a rich source of starch for industrial purpose. Scientific outlook or consideration has not, so far, been brought to bear upon its cultivation and the very ease with which it can be grown has been responsible for this indifference. Its value as a cheap food and a cheap source of starch having been proved by the war, a study of the composition of the chief varieties grown in this State and possible changes during the period of maturity was undertaken. The following conclusions are indicated:—

(1) Edible portion is almost the same in all varieties studied, amounting to 85% of the total weight.
(2) The total carbohydrate content does not show significant variation. But the starch content as estimated by mechanical means varies in different varieties and it appears carbohydrates other than starch are responsible for this variation.
(3) Fat content is almost constant, amounting to 0·5% on the dry basis, in all the varieties examined.
(4) The protein and mineral contents vary with different varieties.
(5) The starch content increases with the time of growth and the maximum content is observed between the eighth and twelfth months. After that period the starch content decreases and there is increase in the fibre content.
(6) The main defect of tapioca as a staple food is its protein deficiency.

50. Investigations on famine rations.

NARAIN DAS KEHAR, Izatnagar.

In order to explore new sources of roughage to allow animals to tide over the famine periods, attempts were made to utilize mature *Typha latifolia* Edgent as the only source of fodder. Feeding experiments conducted over a period of about five months indicated that *Typha latifolia* Edgent supplemented with molasses could maintain animals in good health.

Toxicology

51. Toxicity of *Datura Stramonium* to livestock.

NARAIN DAS KEHAR *and* GOVINDA RAO, Izatnagar.

Studies were undertaken on the toxicity of *Datura Stramonium* to farm animals. It has been observed that (1) the hill variety is poorer in its alkaloidal content than the plains variety, (2) that none of the two has proved to be lethal in its effects even after a prolonged period of feeding.

52. Volatile fatty acids in toxicology.

C. O. KARUNAKARAN *and* K. K. NARAYANA PILLAI, Trivandrum.

Formic and acetic acids have figured in the toxicology of Travancore in a remarkable manner during the last eight years. Prior to 1936 there were no cases of poisoning due to these acids, but since then 71 cases have occurred out of a total of 428 cases in which poison was detected. Formic acid does not appear to have found a place in toxicology elsewhere in India, while acetic acid has been mentioned only once in a decade by the Chemical Examiner to the Government of Madras.

The regional incidence of these cases shows their close association with the rubber industry, in particular with the distribution of the small rubber holders whose store room is a part of the house they live in. The scarcity of the acids resulting from the outbreak of the war has reduced the incidence of poisoning considerably.

In 77% of cases the acids were swallowed for suicide, 18% were accidental. There were no instances of their use for homicide but in three cases death followed deliberate use for relief of stomach pain.

Death might occur within a few hours or within 14 days after swallowing. While 2 ounces of the concentrated acid has been found generally fatal, in a few cases of acetic acid poisoning that dose did not cause death. All formic acid cases were fatal.

The signs and symptoms are those of irritant poisoning and post-mortem appearances show death from asphyxia.

The technique adopted by the authors for the qualitative and quantitative estimation of the acids is described.

53. Studies on sulphanilbenzamide.

A. N. BOSE *and* J. K. GHOSH, Calcutta.

Brownlee and Tonkin (*Nature*, 1941, Aug. 9, p. 167) have shown that sulphanilbenzamide is not much absorbed from the gut of the rabbits. It is being found by us that its absorption in mice, as studied by the blood concentration, is fairly high, a dose of 0·25 mgm./gm. giving a concentration

of 24·2 mgm. of unconjugated drug per 100 c.c. of blood within one hour. No conjugation was noticed within this period. The toxicity of the compound is also found to be low, a dose 2 gm./kg. injected intraperitoneally being well tolerated. In rabbits, of course, the blood concentration does not reach such high level as in mice.

Miscellaneous

54. T-wave abnormalities.

K. R. DORAISWAMI, Madras.

Mechanism of a normal T. Increased amplitude of T—physiologic effect of exercise. Decreased amplitude particularly in Lead II as the result of drugs like Digitalis, Quinidine and Morphine; acute infections, anaemia, hypothyroidism and functional impairment of the myocardium from any cause can also produce this effect.

Notching of the T may occur in hyperthyroidism, during Digitalis medication or in congenital heart disease.

Digitalis T: Spoon-shaped inversion of T with no iso-electric S-T interval.

Hypertension produces inverted T_1 which is shouldered. T_3 is upright and tall and has the reverse appearance of T_1. Coronary occlusion: Immediately after the accident Pardee's T is characteristic. This gradually becomes inverted and becomes 'cover-shaped'. Q waves sometimes assist in locating the infarct.

T-wave changes occur in acute rheumatic fever.

In mitral stenosis, inversion is chiefly due to over-digitalization.

Flattening or depression of $S\text{-}T_{1\,\&\,2}$ and $T_{1\,\&\,2}$ denote coronary sclerosis.

Angina pectoris occasionally produces inversions in Leads I and II.

Myxoedema: Iso-electric or inverted T in all leads are present.

Acute pericarditis: Inversion of T in all leads and also in the chest lead.

Recent investigations show diminished amplitude of T in high altitude flights as the result of anoxia.

Conclusions: T-wave changes represent some factor affecting the myocardium and lend support to the theory that anoxia of the myocardium is a contributing factor.

55. Dusts—their composition and significance.

K. N. BAGCHI *and* ANANDA BHATTACHARJI, Calcutta.

'Dust is the greatest single industrial hazard.' More people are incapacitated for duty because of exposure to dust than for any other cause.

Dusts normally present in the atmosphere are scanty and harmless, but those of industrial origin cause immense harm to the workers and to the population in general. They vary in size from 0·5 to 150 μ. Those within the range of 0·5 and 10 μ are readily inhaled and absorbed into the system.

Dusts are classified by Sayers as toxic, irritant, fibrosis-producing, allergic, bacterial and harmless. The siliceous dusts from quarries, mines and some other industries, where iron and steel are used as raw materials, produce what is called Silicosis or 'miner's phthisis'. Similarly chronic lead and arsenic poisoning may be produced.

The dust is, therefore, a curse of industrialization, or, in other words, of civilization. The study of dust forms the basis of Industrial Hygiene—

an applied science lately developed to protect and improve the health of industrial workers. The scientists who are now busy in planning post-war industrial expansion in India should note that rapid industrialization without developing at the same time organizations for studying Industrial Hygiene is likely to bring unlimited misery to the workers. Such organizations are handled best through governmental agency.

The following table shows the composition of Calcutta dusts (fine dusts from ceilings and tops of book-shelves, cupboards, etc.). The figures compared with those of Leeds indicate appalling backwardness of Calcutta.

The figures indicate percentage.

	Calcutta (1943).				Leeds (1937).	
	Central.	East.	Residential.		Resi-dential.	Indus-trial.
			South.	North.		
Moisture ..	2·3	3·5	3·8	3·7	..	..
Soot, tar and other organic matters ..	20·1	26·5	23·2	24·7	..	..
Silica (silica)..	52·0	49·0	56·0	46·8	..	..
Iron (Fe_2O_3)..	11·9	9·2	5·1	8·4	..	..
Aluminium (Al_2O_3) ..	0·2	trace	trace	trace	..	..
Zinc (ZnO) ..	1·5	0·2	nil	trace	..	..
Calcium (CaO)	9·6	11·1	8·0	15·0	..	..
Copper (Cu) ..	nil	nil	nil	nil	nil	0·041
Lead (Pb) ..	0·0005	0·0017	0·00176	0·0041	0·172	0·302
Arsenic (As_2O_3)	0·0020	0·0006	0·0006	0·0014	0·038	0·047
Sulphur (SO_4)	1·4	..	..	0·85	..	..
Ammonia (NH_3)	0·17	..	..	0·06	..	..
Chlorides (as Cl)	0·16	..	..	0·15	..	..

56. Seasonal variation in crimes.

C. O. Karunakaran *and* K. K. Narayana Pillai, Trivandrum.

The seasonal distribution of the cases of homicide, culpable homicide not amounting to murder and sexual offence investigated medico-legally by the authors during the last eleven years has been studied.

The seasonal variation in temperature and humidity has been calculated.

It is found that there is some correlation between the incidence of crime and rise in temperature. No such correlation is found with reference to humidity.

The period of the year with the maximum temperature is, relatively, the period of plenty; and so economic factors do not appear to be responsible for this difference in the distribution of crimes.

The seasonal variation in temperature is not more than 6°, but the hottest part of the year is the most oppressive period. It may be interesting if similar studies are carried out where seasonal variations in temperature are more pronounced.

57. Medical science in ancient Hindustan.

• R. K. Pillay, Nagercoil (South India).

This paper deals with the evolution of the Hindu system of medicine. It was in existence from the Vedic age, the originators being Punarvasu and Atreya. In the Buddhist age the great Universities of Kasi, Takshasila and Nalanda taught medicine. From Charaka's time this science took proper shape. Its development in its various branches—Medicine, Surgery, Physiology and Anatomy, Midwifery, Bacteriology, Dentistry, Public Health and Sanitation, Vaccination, School Medical Inspection, Nursing, Toxicology, Pule, etc.—is dealt with and eminent authorities quoted in support. Apart from these, the ancient Hindu doctors carried on medical research on a large scale, holding conferences and discussions for the advancement of the science.

SECTION OF AGRICULTURAL SCIENCES

President:—RAO BAHADUR D. V. BAL, M.Sc. (Ag.), PH.D., A.I.C., F.C.S.

Soils—Physics and Physical Chemistry

1. Relation between the size of exchangeable ions and the permeability of soils to water.*

M. R. NAYAR *and* K. P. SHUKLA, Lucknow.

In a recent communication (*Current Science*, 1943, Vol. 12, p. 206) on the influence of the size of exchangeable alkali and alkaline earth cations on the percolation of water in soils saturated with these ions, it was pointed out that the rate of percolation of water followed the order of increasing ionic radius, viz.:

$$\mathrm{Li} < \mathrm{Na} < \mathrm{NH_4} < \mathrm{K} < \mathrm{Rb},$$
$$\text{and} \quad \mathrm{Mg} < \mathrm{Ca} < \mathrm{Sr} < \mathrm{Ba}.$$

These studies have been extended to other di- and tri-valent cations. The above conclusion holds good for analogous metallic ions. The rate of percolation follows the order:

$$\mathrm{Zn} < \mathrm{Cd} < \mathrm{Hg},$$
$$\mathrm{Ni} < \mathrm{Co} < \mathrm{Fe^{++}},$$
$$\text{and} \quad \mathrm{Al} < \mathrm{Cr} < \mathrm{Fe^{+++}}.$$

With analogous ions the rate of percolation (P) and the crystal lattice radius of the ion (r) are related by the empirical relation

$$P = \lambda e^{\mu r},$$

λ, μ being constants.

2. Sodium carbonate method of lining canal beds with a view to minimizing seepage of water. Part V.*

M. R. NAYAR *and* K. P. SHUKLA, Lucknow.

In previous communications (*Proc. Ind. Sc. Cong.*, 1939–43) the results of laboratory experiments on the lining of canal beds with sodium soils were reported. In the last of these papers the possibility of utilizing as a lining material the naturally occurring sodium soil locally known as Usar was discussed. The project has now been put into practice in a portion of a small canal.

A 6-furlong portion of the canal free from outlets was selected for the experiment. The lower half was lined while the upper half was kept as control. One foot of earth was taken out both from the sides and the bed of the canal, an inch layer of Usar soil (selected after analysis) was spread and rammed in, and the dug-out earth replaced. The control portion was treated exactly similarly with the difference that it did not contain the lining material.

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* Carried out under the auspices of the Irrigation Department, Research Section, U. P. Government.

Losses due to seepage were measured simultaneously in both parts of the canal by two methods: (i) the V-notch method when the canal was 'running', and (ii) the compartment method when the canal was closed. Both methods indicated a reduction of 70 to 80% in seepage losses in the lined portion.

Observations are to be continued.

3. Studies on the physicochemical and mineralogical properties of some Indian red and lateritic soils.

S. P. Raychaudhuri *and* Abul Hossain Miah, Dacca.

The mechanical compositions, base combining capacities and buffer curves of profile samples of red soils collected from several parts of Bengal and Southern India have been examined. The mineralogical compositions of the fine sand fractions and the chemical compositions of the clay fractions have also been determined. From general morphological considerations, the soils of Bogra, Jaydebpore, Pasumalai, Midnapore and Bankura appear as red loam, whilst the soils of Tellichery and Bangalore appear as lateritic. From the point of view of the chemical compositions of clay fractions, none of the soils examined can be classed as laterites. Most of the soils should be classed as red loam (SiO_2/Al_2O_3 of clay fraction $>2{\cdot}00$). Soils of Bogra, Midnapore, Jaydebpore, Pasumalai and Bankura are found to be fairly rich in many minerals. On the basis of the variations of buffer capacities of the profile samples, the soils of Jaydebpore, Bankura, Midnapore and Bogra appear to be similar. From the variations of the cataphoretic speeds of clay particles with different concentrations of sodium chloride solutions, it appears that the soils of Bogra, Bangalore and Pasumalai are similar, whilst the soils of Midnapore, Jaydebpore, Tellichery and Bankura form another group.

4. A study of the chemically combined water or the water of constitution of soils with special reference to the soils of C.P. and Berar.

R. H. Joshi *and* D. G. Dakshindas, Nagpur.

Mechanical analysis of soils of the province and also of those from various other provinces does not indicate any relationship between the chemically combined water and the mechanical composition of soils. The chemically combined water, although mostly present in the clay fraction, is also seen in an appreciable amount in the silt and sand fractions.

The chemically combined water bears a linear relationship with the R_2O_3 and also with Fe_2O_3, as determined from HCl extract, both in the case of soils and clays. It appears, therefore, that the water combines only with iron and aluminium parts of the rock material and turns them into hydrated iron and aluminium silicates. In the case of laterites and lateritic soils there appears to be dehydration taking place during laterization. As the combined water percentage and the $\frac{SiO_2}{Al_2O_3}$ ratio vary within the very narrow limits of 3 to 4 and 7 to 9 respectively, the climatic conditions prevalent in the province appear to be responsible for the formation of similar types of clays.* The colour of the soils tends to vary with

* The base exchange capacity of soils does not properly indicate a relationship with the combined water, although generally the base exchange capacity is high with soils having a high percentage of combined water.

the amount of combined water, the higher the percentage of combined water the deeper is the colour.

5. Identification of kaolinite in clays by electrochemical methods.*

R. P. Mitra *and* T. D. Biswas, Calcutta.

Hydrogen clays prepared from the entire clay fractions of a Belgaon laterite and a red earth from Coimbatore and also from three subfractions isolated from the red earth by controlled centrifugalization of its entire clay fraction behave as dibasic acids judged from the nature of their potentiometric titration curve with NaOH. The first inflexion in the titration curve occurs between pH 6·5 and 8·0 and the second between pH 8·0 and 9·0. The ratio of the base exchange capacities at the two inflexion points is nearly 2·0. Similar electrochemical features are shown by hydrogen kaolinites prepared from two pure specimens of the mineral and this similarity points to the presence of kaolinite in the above clays.

6. Differentiation of hydrogen clays and identification of secondary silicate minerals contained in them by viscous and electrochemical methods.*

R. P. Mitra, M. K. Indra *and* B. G. Ray, Calcutta.

Six hydrogen clays prepared from the entire clay fraction of a black cotton soil from Satara and five subfractions separated from this entire clay fraction by controlled centrifugalization in a Sharples Supercentrifuge, behave as *monobasic* acids, judged from the nature of their potentiometric titration curves with caustic soda. The hydrogen clay from the entire clay fraction of a red earth from Coimbatore, on the other hand, shows a *dibasic* acid character. X-ray and thermal measurements indicate that the Satara clays have montmorillonite as their major mineral constituent while kaolinite is the dominant mineral contained in the clay fraction of the red earth. On the addition of increasing amounts of alkali to a 2·0% suspension of the montmorillonitic clays, their viscosity at first increases, passes through a maximum at a point corresponding approximately with 70% neutralization of the amount of the acid indicated by the inflexion point in the titration curve, and then the viscosity decreases. Yield value appears near about 30% neutralization and like the viscosity, the yield value at first increases, passes through a maximum at about 70% neutralization, then diminishes and finally disappears. The plot of the buffer capacity, $\beta\left(=\frac{\delta\beta}{\delta p\mathrm{H}}\right)$, against percentage neutralization also shows a maximum, but it occurs at different stages of neutralization in the case of the six hydrogen clays. Comparing the five subfractions it is found that the smaller the particle-size the greater are (*a*) the original viscosity, (*b*) the variations of the viscosity on the addition of the alkali, and (*c*) the amount of the acid per gramme of the hydrogen clay which reacts with the alkali at the inflexion point of the titration curve. Unlike the montmorillonitic clays, the kaolinitic hydrogen clay from the red earth shows practically no change in the viscosity till about 100% neutralization is reached after which the viscosity sharply decreases. No yield value is observed at any stage of the neutralization using a 2% suspension

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* The work has been carried out under a scheme of research financed by the Imperial Council of Agricultural Research and directed by Prof. J. N. Mukherjee.

7. Interaction of hydrogen clays with acids.*

B. CHATTERJEE, Calcutta.

On the addition of increasing amounts of phosphoric and oxalic acids to hydrogen clays Padegaon-B and Latekujan-F prepared respectively from a calcareous soil (B-type) from Padegaon (Bombay) and an acid soil from Latekujan (Assam), more and more silica and sesquioxides are dissolved, and oxalate and phosphate are adsorbed in increasing quantities. On treatment with oxalic acid the b.e.c. of Latekujan-F decreases by 29·0% and that of Padegaon-B by 10·7% indicating a decomposition of the absorption complex. The treatment with phosphoric acid, on the other hand, brings about a marked increase in the b.e.c., 15·0% for Latekujan-F and 19 0% for Padegaon-B. The observed increase in b.e.c. is not equivalent to the amount of phosphate adsorbed.

8. The effect of concentration on the capillary movement of some salt solutions through the black cotton soil.

L. A. RAMDAS *and* A. K. MALLIK, Poona.

In two recent papers (*Proceedings of the Indian Academy of Sciences*, Vol. XVI, 1942) the capillary ascent of water and certain solutions through black cotton soil as well as the swelling of the colloidal cover of the soil particles have been discussed. The present paper describes the effect of varying the concentration of solutions of lithium carbonate, sodium carbonate, oxalic acid, lithium oxalate and sodium oxalate on their rate of ascent through soil columns. It is found that as the concentration is increased from zero to a small critical value C_x, the rate of ascent increases. The capillary ascent decreases with concentration above C_x till finally the soil becomes almost impermeable.

Further work is in progress.

9. An electrical method of studying the movement of water through soil and the structure of the water front.

A. U. MOMIN, Poona.

The paper describes an electrical method used in the study of the structure of an ascending water front in a soil column and the variations in the electrical resistance of the soil in relation to its moisture and salt content. The method described is, in essential principles, similar to that due to Kohlrauch; but by making use of thermionic valves and the electron-ray tube the accuracy and the range of measurable resistances have been greatly extended. The superiority of the electron-ray tube over the telephone as a null point indicator is discussed.

The results of the experiments described show that the upper limit of the visibly wetted soil column does indicate the position of the water front. The possibility of using the method in studying the movement of moisture in the soil under actual field conditions has been indicated.

Soils—Chemistry

10. Patiala soil.

L. D. MAHAJAN, Patiala.

Soil and subsoil of Patiala were studied for horticulture and economic crops. Different plots of uncultivated lands, varying in areas and location

* The work has been carried out under a scheme of research financed he Imperial Council of Agricultural Research and directed by P of.J. N. Mukherjee.

were selected outisde the city walls (either barren or covered with forests). Samples of soil were drawn with a standard auger, up to eight feet depth, and the beaker-basin method was used for aggregate analysis. Chemical aspect of soil was also examined. Though the properties of soil vary from place to place and with time, the following general results can be concluded :—

(i) The surface soil and the first three feet layer of the soil are mostly loam or clay loam. The drainage is quite adequate.
(ii) The lower layers show the presence of a large quantity of lime gravels of irregular shape and light yellow, soft clayey soil called the 'Pandu'. The 7th to 8th ft., which contains large quantity of Pandu, permits very poor percolation of water.
(iii) This soil is generally deficient in organic matter, total nitrogen and phosphates.
(iv) The surface soil is satisfactory for cultivation of almost all economic crops except those preferring semi-aquatic and aquatic conditions.
(v) The deep-rooted trees, if grown, will have slow progress.

11. Influence of humic manures and crop rotation on the conservation of soil properties.

A. Sreenivasan, Indore.

This paper reports the results of a detailed study on the changes in soil properties following a four-year crop rotation, viz.: (i) cotton, (ii) *sann*, ploughed in and followed by wheat, (iii) groundnut, and (iv) *jowar*, with and without the humic manures: farm compost, municipal compost and farmyard manure. It is revealed that the physical condition and chemical composition of the soil are maintained, as a result of crop rotation, even in the unmanured plots. This is no doubt due to the periodic addition of a green manure as also the inclusion of a legume in the rotation. There is, however, a significant contrast between the untreated and humic manured plots, accounting for the differences in their productivity. This is seen in the remarkable and steady increase, over a period of years, in nitrogen and, especially, carbon contents of soil from the manured plots. Even exposure of these humus-rich soils for nearly six months which included the hot summer months of April to June has not resulted in any appreciable loss of these constituents. This conservation of carbon and nitrogen through humic manuring would suggest that the general fertility of the soil can, without limits, be maintained at high levels and within an expense that may be justifiable in terms of a rotation of crops.

12. Fixation of phosphate by cultivated soils. Part I.

B. Vishwanath, New Delhi, *and* D. K. Patel, Baroda.

A laboratory method for comparing the fixing capacities of soil is discussed in detail. Forty-two surface soils, typical of all soil types of India are classified according to their phosphate fixing power. In general, the soils of Northern India from Assam to Punjab are of low fixing power, the soils of Southern India including coastal parts are of medium fixing capacity and the black cotton soils of Central India including C.P. are of high fixing capacity. The soils are, further, classified according to their phosphate-fixing capacity in relation to the colour of the soils. Black soils have highest fixing power while brown soils are of low fixing capacity. The red, pink and grey soils are intermediate in this respect. Soils of arid and per-arid regions are low fixing while the soils of semi-arid and humid regions, nearly equal in their fixing capacity, have high fixing power.

13. Fixation of phosphate by cultivated soils. Part II. Effect of *p*H, calcium content, clay percentage, SiO_2/R_2O_3 ratio, $Fe_2O_3+Al_2O_3$ content, total exchange capacity, total exchangeable base.

B. VISHWANATH, New Delhi, *and* D. K. PATEL, Baroda.

The meaning of phosphate fixation is examined, and the effects of *p*H, clay content, total exchange capacity, exchangeable bases with special reference to exchangeable calcium, SiO_2/R_2O_3 ratio, iron and aluminium content and calcium carbonate content are briefly outlined. They are directly related to phosphate fixation except SiO_2/R_2O_3 ratio which is inversely related to phosphate fixation in soils.

The chemical and physicochemical theories of phosphate fixation are reviewed and discussed in the light of the results obtained. It is concluded that adsorption and absorption (physicochemical theory) are minor causes of phosphate fixation and that chemical precipitation (chemical theory) accounts for most of the phosphate fixation in soils.

Crops —Husbandry

14. Crop response to pre- and inter-cultivation.

A. SREENIVASAN, Indore.

A review is given of experimental work on the effects of primary and inter-row tillage on crop yields with special reference to their bearing on the present-day concept of soil-moisture relationships. This is followed by details of certain experiments carried out, during several seasons, under Malwa conditions. These have shown that (1) the present method of the Malwa cultivator of giving a few hot weather *bakharings* before *kharif* sowings, is not likely to be improved by introducing additional and deeper cultivations, and (2) the favourable influence of interculture is due solely to its efficiency in removing weeds and not to its capacity to produce a mulch. Excessive interculture by implements has, in fact, an adverse effect on crop yields due to the loss in soil tilth and mechanical injury and mortality to standing crops resulting from the bullock tramplings and the pressure of the implements.

It is concluded that the development of soil cracks during summer fallow brings about a result similar to cultivation by a process of self-ploughing and subsoiling.

15. Sugarcane varietal trials conducted on the Bilaspur farm, C.P., during the period 1932–1942.

V. G. VAIDYA, Raipur, *and* D. V. BAL, Nagpur.

1. An account of sugarcane varietal trials carried out on the Bilaspur farm, C.P., during the period 1932–1942 has been given.

2. As a result of the work on sugarcane prior to 1932, the then local varieties *Bangla* and *Malagar* were completely replaced by *Khari* and this variety was subsequently replaced by the Coimbatore varieties, Co 210 and Co 237.

3. Twenty-four more varieties of Coimbatore canes were brought under trial during the period 1932–1942. Field trials and determinations of sucrose and glucose, etc. were carried out and observations regarding incidence of pests and diseases in respect of the different varieties were recorded.

4. Cos. 313, 312, 349, 419 and 421 have proved their superiority over Cos. 210 and 237 in respect of sucrose content, cane and *gur* weight per acre and general performance.

5. The order in which the varieties come to maturity is Cos. 313, 312, 210 and 237.

6. Co 421 is an early ripener like Co 313.

7. Co 349 and Co 419 appear to be medium and late canes and may replace Co 210 and Co 237.

8. If the varieties, Cos. 313, 312, 349 and 419, are grown in proper proportions, the cultivators can easily have a continuous cane crushing period of 4½ months.

16. Improvement of lac crop production on *Butea frondosa* (Palas) by artificial partial defoliation.

P. S. Negi, Namkum.

Due to adverse climatic conditions in the *Baisakhi* crop (October to June-July) and low biological activity during the greater part of summer in Palas, the cultivator resorts to *Ari* (immature) crop cutting. This practice results (i) in yielding only about half as much crop as could be produced if the lac insects survived in normal numbers as they do in the *Katki* (June to October) crop when such adverse conditions are absent and the biological activity of the host is normal, and (ii) in scarcity of brood lac to infect the succeeding *Katki* crop and therefore an extremely disproportionate distribution of trees to cultivate the *Baisakhi* and the *Katki* crop.

To overcome the above conditions, artificial partial defoliation of Palas before infection of the *Baisakhi* crop is being tried for the last three years. The experimental technique was attended with the following results: (i) economy of brood lac to the extent of over one maund (82 lbs.) for every 100 trees was effected; (ii) in July 1941 due to severe summer, the control trees did not yield practically any brood lac while the experimental trees yielded over 129 lbs.; (iii) in July 1942, in spite of the extreme summer experienced for over past ten years, the experimental 68 trees yielded 157 lbs. of brood lac against about 1¼ lbs. only of poor quality brood from 100 control trees; (iv) in July 1943, under the normal summer, the brood lac survived in 59·2% of experimental trees as against 31·8% of control; the control trees could not spare any brood lac to infect artificially any other tree, but the experimental trees yielded a surplus of about 152 lbs.

Crops—Physiology

17. On the pre-sowing treatment: the water relations of the treated and control plants.

P. Parija *and* K. P. Pillay, Cuttack.

In an experiment on the pre-sowing treatment of paddy with a view to inducing drought resistance, the transpiration rates of treated and control plants were studied on a statistical basis. The results obtained seem to be highly promising and interesting.

It is evident from the analysis of variance of the data that the water transpired by the treated plants is significantly less than that by the controls. Further, the treated plants seem to have a consistently high leaf water-content. It appears that the marked differences in transpiration rates between treated and control plants are reflected in their respective leaf water-content.

18. Relation between the temperature and humidity at the time of ripening and the period of dormancy in *Oryza sativa.*

P. Parija, Cuttack.

While investigating the breaking of dormancy in the paddy, data on maximum and minimum temperatures and humidity were collected with a view to see if they have any relation to the period of dormancy. It is found that (1) the minimum temperature has a negative correlation with the length of dormant period; (2) the difference between the maximum and the minimum temperatures shows a sort of positive correlation; (3) the maximum temperature has no correlation; and (4) the humidity also does not show any correlation at all.

19. Effect of carbon dioxide on plant growth.

R. K. Misra, Poona.

In a communication to the Indian Science Congress, 1943, the author described a method for taking out air from soil and analyzing this for carbon dioxide content. Some of the results obtained are briefly described. It has been shown that the amount of carbon dioxide in the soil air increases suddenly as a result of irrigation and then decreases again as the soil dries out. The effect of supplying carbon dioxide through irrigation water to wheat, cotton and paddy plants grown in pot culture has also been studied. It has been shown that application of carbon dioxide has in every case, resulted in a better vegetative growth.

Crops—Genetics

20. Dimeric transmission of disease resistance to *Ustilago Avenae* (Pers.) Jens. *Race 21* (Reed) in Avena hybrid of interspecific derivation.

N. M. Patel, Anand (Bombay).

Genetic knowledge concerning the nature of inheritance of disease reaction in agricultural crops including forage plants, forms the basis of plant breeding when immunity or resistance to a disease or diseases prevalent in a given tract is sought for in combination with agronomic characters such as adaptability, high yield, earliness, and other desirable characteristics. Series 1060 Lot-44 L.W. was extracted from an interspecific cross made between *Avena barbata* Pott. and *Avena sativa* L. The former carries 28 and the latter 42 chromosomes in their diploid or somatic cells. Series 1060 Lot-44 L.W. is early ripening variety and has dull-coloured, long karyopsis but is susceptible to the invasion of the loose smut pathogen, *Ustilago Avenae* (Pers.) Jens. *Race 21* (Reed), which myco-geographically is the Ithaca Race. Smut Resistant (Cornell)-6 (C.I. No. 3610) is a mid-season variety coupled with heavy yield and plump grain. It is a near-immune variety and resists the attack of all the U.S. pathogenetic races except races No. 19 of the loose smut organism which mildly attacks it. In a cross between Series 1060 Lot-44 L.W. and Smut Resistant (Cornell)-6, the F_1 showed resistance to the invasion of *U. Avenae.* In F_2, there was segregation for the disease reaction into 48 smutted plants as against 524 non-smutted plants, in six cultures, with a total X^2 of 8·764 on the basis of dimeric gene hypothesis. The X^2 value gives a good fit. In the F_3 generation 4 families were found to be segregating for 3:1 ratio, 11 families were segregating for 15:1 ratio, and 20 families were found to breed true for disease resistance. The results show that loose smut resistance behaves as a dominant response

over smut susceptibility. Series 1060 carries two pairs of recessive genes ($r_1r_1r_2r_2$) and Smut Resistant (Cornell)-6 contains two dominant allels ($R_1R_1R_2R_2$) in its genotype. Independent segregation takes place and in the F_2 generation 15 resistant : 1 susceptible ratio is obtained. F_3 results add confirmatory evidence to the dimeric gene hypothesis advanced to explain the nature of loose smut inheritance in this cross.

Plant—Chemistry

21. Studies on the relation of chemical composition and quality of Virginia tobacco.

C. C. SHAH *and* B. M. PATEL, Baroda.

An attempt has been made to correlate quality of tobacco with its chemical composition. It has been shown that it is mainly the percentage of nitrogen that keeps the grade of tobacco low. Superior tobaccos are poor in nitrogen and magnesium and rich in potassium and phosphate.

A grade 1 tobacco contains 15% of potash, 7% of phosphate and 5% of magnesium on the ash basis and only 0·9% nitrogen. A low grade tobacco would contain 8% of potash, 2% of phosphate and 10% of magnesium on the ash basis and the nitrogen may be as much as 2%.

Animal Nutrition and Dairy Chemistry

22. Some new feeding stuffs.

D. K. PATEL *and* C. C. SHAH, Baroda.

The seeds of *Cassia Tora* (N.O.—Leguminosae, Hindi—Chaoda-arak, Marathi—Kawario, Guj.—Tankala-kowaria, Tamil—Tagarisha-chettu) and *Crotaria medicaginea* (N.O.—Leguminosae, Guj.—Zenzru) growing in abundance as wild plants in Gujarat and in tropical regions of India, have been found as good cattle feeds and can serve as substitutes for Guar and cotton seeds in these days of war. The ether extract percentage, proteins and carbohydrate contents of the seeds of *Cassia Tora* and *Crotaria medicaginea* are 7·18% and 6·76%, 20·24% and 23·31%, 59·45% and 42·04% respectively. Cooking with common salt makes them palatable.

23. The significance of calcium in the undigested fibrous food residue in the faeces of ruminants.

S. C. RAY, Izatnagar.

A detailed experimental study has been made on the possibility of mechanical subdivision of faeces with a view to separate quantitatively faecal fibrous food residue and to estimate the calcium and other nutrient constituents present in it.

The results of the experiment have shown that by a standardized method it is possible to separate a definite fibrous entity in the faeces of ruminants. The quantity and composition of this fibrous food residue in faeces are dependent mainly on the nature of the roughage fed to the animals.

The fibrous food residue in faeces and its calcium content were determined in a group of animals kept in turn under three different cereal straws, viz. Paddy, Wheat and Barley. It was found that the dry matter of food residues was directly proportional to the dry matter of different straws consumed, but in spite of the lowest ingestion of calcium in paddy straw the excretion of the mineral was the highest in the faecal

food residue. The percentage of calcium in the fibrous residue in faeces was 40, 26 and 20 and the calcium content per 100 gm. of dry fibrous food residue was 0·535 gm., 0·400 gm. and 0·420 gm. respectively for paddy, wheat and barley straws; these figures suggest that comparatively a larger proportion of calcium is locked up in the cells encased by indigestible fibre in the case of paddy than in other two cereal straws examined.

To verify whether calcium utilization in paddy straw can be improved by alkali treatment which is expected to reduce the losses of the mineral in the faecal residue, the latter was collected both under untreated and alkali-treated straw feeding and the calcium in the residues was estimated. The results show that by the alkali treatment of paddy straw the percentage loss of calcium in the faecal fibrous residue can be reduced from 40 to 19.

24. Manufacture of condensed milk from market milk sold in India.

R. V. Ghate *and* N. V. Joshi, Poona.

The question of turning market milk sold in India has been investigated. A large proportion of market milk in India is buffalo milk. Whole buffalo milk on account of its large percentage of fat causes excessive frothing during evaporation. It has been found that it is more convenient to reduce the percentage of fat in the milk to be condensed before commencement of evaporation. After the process of removing the excess of water by evaporation is complete, the milk may be poured in tins and heated to 110°C. under pressure and preserved for any length of time. However, there is some change in the milk at this temperature. Whether there is any change in the digestibility of casein is not yet definitely ascertained.

If instead of heating to 110°C. under pressure, the condensed milk is heated to 100°C. only, spoilage occurs in a large percentage of samples of such milk. This has been found to be due to the presence of spore-forming organisms in the milk samples used for condensing. We have, however, overcome this difficulty without the necessity of heating the samples beyond 100°C. by adopting the following procedure:

When the evaporation is completed the milk samples are heated to 100°C., cooled down and then incubated at 37°C. for 3 to 3½ hours, after which period the samples are again heated to 100°C. for ½ hour. This procedure has been found to be very effective in preventing spoilage of condensed milk.

There is a possibility of reducing the temperature of heating the condensed milk to less than 100°C. but it is considered safer at present stage of our investigation to heat the condensed milk to 100°C. to preserve it for any length of time.

25. A comparative study of the quality of ghee from cow and buffalo under uniform dietary conditions, including heavy feeding of cotton seed.

M. D. Patel, B. M. Patel *and* C. N. Dave, Anand (Bombay).

Experiments have been conducted to study the effect of identical diet on the physical and chemical constants of ghee prepared from the milk fat of two milch species, namely, Kankrej cow and Surati buffalo. The results show that Butyro Refractometric value, Polenske value and Acid value are significantly higher and Saponification value, Reichert Meissl value and Kirschner value are significantly lower for the ghee from the milk fat of cow than of buffalo.

The effect of the replacement of the concentrate mixture in the production ration entirely by cotton seed shows that in the ghee from both cow and buffalo the B.R. value increases but all other constants

show a decrease. The qualitative change brought about in ghee by cotton seed feeding is more pronounced in buffalo-ghee than in cow-ghee.

The limits of variations in the constants of ghee from cow and buffalo under the present conditions of study have been discussed along with the data of other workers.

26. Investigation on the physicochemical constants of the solid and liquid phases of ghee.

C. C. SHAH, B. M. PATEL *and* D. K. PATEL, Baroda.

Ghee was kept standing and permitted to separate into two layers at room-temperature, 30°C. The solid and the liquid phases were analyzed and it has been found that there is no effect on the Polenske value, Iodine value and the Butyro Refractometer readings of the two components.

The liquid phase contains more of the butyric, caproic, and capric acids, while the content of the myristic and lauric acids is equally distributed between the two phases. The saponification value of the liquid phase is greater showing that the liquidity of the phase is mainly due to the presence of the higher proportion of the lower fatty acids. The free acid also remains to a larger extent in the liquid phase.

27. A comparative study of two 'desi' methods of manufacture on the yield and quality of ghee.

M. D. PATEL *and* C. N. DAVE, Anand (Bombay).

Experiments have been carried out to study the effect of two well-known *desi* methods of manufacture, viz. Gujarat method and Khandesh method on the outturn, physical and chemical constants and market value of ghee.

For the purpose of the experiment ghee was prepared by G. and K. methods from the milks of both cows and buffaloes. During the course of the investigation the animals of both the species were kept under the same production ration which consisted of (*a*) a dairy concentrate mixture for one group of the experimental animals, and (*b*) sole cotton seed feed for the other group of animals.

The results of the study indicate that (1) by the Khandesh method, under either production ration, significantly higher yield of ghee is obtained from the milks of both cows and buffaloes, the higher yield being considerably more marked from cow's milk than from buffalo's milk; (2) no appreciable difference is noticeable in the physical and chemical constants of ghee prepared by the two methods, and (3) the market value of Khandesh-ghee is definitely superior to Gujarat-ghee due to its better flavour and physical appearance.

Methods of Analysis

28. A simple precision temperature apparatus (an electric thermo-regulator).

D. K. PATEL *and* C. C. SHAH, Baroda.

A simple and accurate precision temperature apparatus has been evolved. It consists of a U-tube joined to a bent tube with a bulb. The make and break of the circuit is controlled by the change of the mercury levels in the U-tube, governed by the change in volume of the liquid in the bulb. It can be directly connected to the mains using a lamp heater or a coil heater. Temperature can be maintained up to $\pm 0{\cdot}1$°C. by choosing a proper liquid or a mixture. The apparatus can be prepared easily in a laboratory and has a great advantage of cheapness.

29. Application of Pulfrich photometer and photoelectric colorimeter for phosphate estimation.

B. VISHWANATH, New Delhi, *and* D. K. PATEL, Baroda.

A sensitive, accurate and rapid method for the determination of phosphate, involving the application of the photoelectric colorimeter and Pulfrich photometer to the ceruleomolybdate reaction is described.

Results in this case are found to be well agreeing with the results of volumetric method of estimating phosphate by phosphomolybdate precipitation. The method of Fiske and Subbarow, adopted here, has the advantage over the Deniges' method for (1) proportionality between colour development and amount of P_2O_5 over a wide range; (2) relative freedom from interference by such substances as ammonium, iron salts, nitrites, nitrates, silicates and chlorides; (3) stability of colour over a wide period.

30. Note on 'the Warren and Pugh method of estimating phosphate in HCl extracts of soils'.

B. VISHWANATH, New Delhi, *and* D. K. PATEL, Baroda.

The method recommended by Warren and Pugh for the estimation of hydrochloric acid soluble phosphoric acid is found to be unsatisfactory. The *p*H adjustment to 6·8 by colour change as mentioned by Warren and Pugh is not accurate. It shows a wide range. 3·5 c.c. of 2*N* sulphuric acid do not adjust the *p*H to 3·0. The *p*H differed from soil to soil. Phosphate determinations varied considerably in the same sample.

Manures and Fertilizers

31. Accumulation of phosphates in soils under sewage irrigation and its adverse effect on plant growth and crop production.

S.C. PILLAI, R. RAJAGOPALAN *and* V. SUBRAHMANYAN, Bangalore.

From the chemical point of view the distinctive feature of soils under continuous sewage irrigation is the accumulation of phosphorus in the soil, the phosphorus being mostly in an unavailable condition. Our preliminary experiments show that this accumulation of phosphates acts as an indicator of a limiting factor in the sewage farming practice. Russell (Soil Conditions and Plant Growth, 1937, p. 79) has reported reduction in crop yield as a result of excess of phosphates in the soil. More recently, Rege (*Ind. Journ. Agri. Sci.*, 1943, Vol. 13, Part I, p. 109) has also observed a similar deleterious effect due to accumulation of phosphate in the soil from oil-cakes which were used as nitrogenous top-dressings to sugarcane.

Our experiments have also shown that the adverse condition indicated by the accumulation of phosphates in sewage sick soils can be considerably mitigated by a basal dressing of burnt lime.

32. Influence of burnt lime on the fertilizing action of raw sewage in soil.

S. C. PILLAI, R. RAJAGOPALAN *and* V. SUBRAHMANYAN, Bangalore.

With a view to studying the nature and extent of the fertilizing action of raw sewage in the soil and also the effect of various chemical treatments of the soil prior to the direct application of sewage, a series of experiments were carried out in pots and plots. The chemical treatments included application of burnt lime alone, lime along with ferrous sulphate,

and other chemical oxidizers. In the pot trials (lime at the rate of ½ ton per acre with raw sewage), the percentage of increase in yield in the case of tomatoes was about 40 and that in the case of French beans was about 30. In plots the percentage increase was about 20 in the case of tomatoes, and about 28 in the case of Jowar (plot experiments with other crops are still under way).

Varying dosages of lime were tried in pots and it was observed that amounts at the rate of one ton per acre yielded the best results for the Bangalore soil and for the sewage used.

While the application of burnt lime to soils is almost a general practice in European countries where soils are naturally rich in organic matter or which receive comparatively more organic matter, it is suggested that the soils under sewage irrigation may be limed with advantage both in India and elsewhere. The quantities of lime to be applied will vary with the type of soil as also the strength of sewage.

Plant Pathology

33. Study of vaporization of mercury with reference to its insecticidal application.

K. K. Dole, Poona.

Since mercury vapour appears to be detrimental to insect eggs and small larvae affecting the stored food grains, it appears that it acts as a fumigant and not as a contact or stomach poison. So the emission of mercury vapour from its different preparations is the deciding factor of their efficiency as insect preventives. It is observed that mercury amalgams are poor emitters of mercury vapour while dispersions of mercury (dusts) in neutral substances prepared by chemical precipitations or physical methods are more efficient in this respect. A method of testing the efficiency of different preparations is developed in the present investigation.

34. Determination of the minimum quantity of mercury for preservation of stored food grains from insect attack.

K. K. Dole, Poona.

In continuation of the previous work on studies of insecticidal properties of mercury, the determination of minimum quantity of mercury essential for prevention of insect attack is studied in the present paper. The insect attack is prevented by keeping the surrounding space of the grain saturated with mercury vapour. Very small quantity of mercury is required for this purpose and it is found that about one gram of mercury, properly dispersed, is more than sufficient to preserve 250 lbs. of grain. The form in which the metallic mercury is used is important and interstitial space between the grains appears to be one of the important factors affecting the diffusion of mercury vapour around the grain. Mercurous chloride also has been found to be effective towards prevention of insect attack in stored food grains.

35. Fruit-sucking moths of the Deccan.

T. V. Ramakrishna Ayyar, Hyderabad (Deccan).

It is well known that fruit trees of different kinds all over the world are found subject to the attacks of the caterpillars of numerous moths in different categories such as leaf and bud-eaters, stem-borers, fruit-borers, etc.; but so far we have very few examples of moths causing direct damage in their adult stage to cultivated crops. The damage thus caused consists in these moths appearing during nights in orchards,

puncturing the ripening fruits and sucking up the fruit juice. It is at the same time peculiar and surprising to note that in the immature stages these insects (caterpillars) are never found feeding on any of the fruit crops their parents attack. The chief insects so far noted as causing this kind of damage are moths of the family *Noctuidae* and the most notorious among the members of this family are species of the genus *Ophideres* (*Othreis*) which are stout, well-built insects beautifully and cryptically coloured. Species of *Ophideres* have been noted from most of the tropical areas such as Africa, India, Malayasia, Australia and even Japan. In the Deccan also moths of this species have been noted as causing damage to fruit trees in the different tracts; and in addition, other moths have also been observed and collected. In this paper ar attempt is made to present a brief summary of the notes so far made on these insects in the Deccan.

36. Biology of *Stromatium barbatum* Fabr.

R. L. Gupta, Nagpur.

The beetle is widely distributed. Its larva is a borer and is a pest of a large number of forest trees but also attacks a variety of trees in the plains. The recorded food plants are about 311 belonging to 54 different natural orders. In the Central Provinces it has been found to attack teak, *Acacia catechu*, mango, orange, lemon, *mosambi*, pomegranate, Haemotoxylin, *Casurina*, *Bauhinia variegata*, jack-fruit and *Albizzia lebbek*. It is particularly a bad pest of citrus trees in the Central Provinces. Young citrus trees are not attacked but those over 12 to 13 years are infested, older ones being more susceptible. It is not only a dry wood pest but also a pest of green trees. A survey made in Nagpur of several orchards over 15 years old showed the attack varying from 75 to 80%. The eggs are deposited in the month of June, in cracks or crevices in the bark, whether dry or wet, either singly or in groups. The maximum number of eggs laid by a female in captivity was noted to be 343 and minimum 183. Egg stage varies from 6 to 11 days, 54 to 85% of eggs being viable under laboratory conditions. About a week after hatching, the larva bores into the stem making horizontal, vertical and transverse galleries. It continues to do damage for about 2 years or more. The larval period ranges from 2 to 5 years or even more. Pupation takes place in May and the adults emerge in May and June. Pupal period is 14 to 18 days. Mating takes place soon after emergence and the females lay eggs. Pre-oviposition period is 2 hours to 2 days. Adults are not seen after the first week of July.

37. 'Red leaf' in *G. hirsutum* cotton.

K. Ramiah *and* Bhola Nath, Indore.

The occurrence of redness in the leaves of *hirsutum* cotton plants, which is considered a blight, may be of two kinds. In one the redness appears uniformly over the whole of the upper surface of the leaf and this behaves as a Mendelian character. In the other the redness appears in patches on both the surfaces and this redness associated with a curling or crumpling of the leaf is considered the result of Jassid attack on the plant. While the latter may cause serious loss of crop the former in the absence of Jassid incidence may be a desirable character, particularly in rain-fed cottons, as it causes extra earliness in the plant.

38. 'Phyto-nematology': an untrodden path in India.

G. D. Bhalerao, Izatnagar.

The term 'Phyto-nematology' is proposed for the study of nematodes affecting plants. The extent of the ravages and grave potentialities of

plant parasitic nematodes, especially in relation to the ever increasing cultivation of tropical crops, is being realized acutely today by agriculturists and horticulturists alike all over the world. It is therefore highly surprising that in spite of the great economic importance of phytonematology this subject has so far received practically no attention in this country. The object of presenting this paper is to call attention of the agricultural zoologists to this fascinating and highly economic branch of research and to stimulate them to pursue this line of investigation. To illustrate his point of view the writer has selected eleven species of nematodes, only four of which have so far been known to occur in India. In each case reference has been made to the important plants affected by the parasite, its life-history, the damage it causes and the control measures.

39. Further trials with *Trichogramma* parasites for the control of the cotton bollworms (*Earias* and *Platyedra*) at Coimbatore.

M. C. CHERIAN *and* V. MARGABANDHU, Coimbatore.

In this paper are set forth the results of field liberation of *Trichogramma* parasites for the control of the cotton bollworms for the second time. Four fields were taken up for experimentation with two as controls and two for the release of parasites. The parasites were liberated at the rate of 10,000 per acre once in four days, with eighteen liberations in all covering the first flush. The effect of liberation was determined by noting the relative infestation among burst bolls from control and released plots. In all 18,688 burst bolls comprising 73,582 locks were examined. Reduction in incidence in the treated plots was noted this year also.

40. Studies on the effect of temperature and humidity on the different stages of *Platyedra gossypiella* Saunders.

M. C. CHERIAN *and* V. MARGABANDHU, Coimbatore.

This paper records the results of studies made on the effect of various temperatures and humidites on (i) larvae, (ii) pupae, and (iii) adults of the pink bollworm. They were subjected to the following temperatures, viz.: 5°C., 15°C., 20°C., 25°C., 30°C., 35°C., 38°C., 40°C., 45°C., 50°C. and 60°C., the relative humidities being 0%, 20%, 40%, 60%, 80% and 100%.

In the case of larvae it has been found that temperature and humidity in themselves have not been able to induce diapause. At 5°C. the larvae die without pupation. While they pupate at 38°C. there is no emergence of moths from pupae. With regard to pupae, there was no emergence of adults at 5°C. While the emergence is normal at 15°C., 20°C., 25°C. and 30°C., it is at its minimum at 35°C., with no emergence at 38°C. 0%, 20% and 40% relative humidities are unfavourable for adult emergence. Irrespective of the different humidities, the average pupal period is 26 days at 15°C., 15 days at 20°C., 11 days at 25°C., and 7 days at 30°C. The different humidities by themselves have had no effect on the pupal period. Maximum longevity in adults was obtained at 15°C.

Agricultural Meteorology

41. Sunshine over India.

C. SESHACHAR *and* T. V. RAMACHANDRA AIYAR, Bangalore.

This paper analyzes the hours of bright sunshine over eleven stations, viz. Trivandrum, Kodaikanal, Madras, Bangalore, Poona, Bombay,

Calcutta, Agra, Jaipur, Karachi and Lahore. It is found that the duration of sunshine increases with latitude, but decreases with altitude. July is the month with the least hours of sunshine and the duration of sunshine is longest generally in March.

Agricultural Statistics

42. Observations on sugarcane.

A. K. MALLIK *and* P. S. SREENIVASAN, Poona.

The paper gives an account of a study of the growth of a sugarcane crop by sampling. The sampling method is described. The march of the growth features (1) number of canes, (2) number of leaves, (3) height of the cane, and (4) brix reading of the crop for a period of about five months is briefly described. The mean values of the above growth features for the different days of observation as well as the sampling error of the mean and the coefficient of variability are given. It is concluded, on the basis of the statistical analysis of the data that the sampling method is satisfactory.

43. Sampling studies on jowar.

S. GOPAL RAO *and* P. V. PIMPALWADKAR, Poona.

Three 'parallel' methods of sampling were tried on jowar. The sampling unit consisted of two metre lengths of drill, measured one metre along one row and the other along the adjacent row, the two metre-lengths being opposite. The three methods differed from one another in the selection of the rows sampled. A table showing the analysis of variance is given.

SECTION OF PHYSIOLOGY

President :—S. N. Mathur, M.B.B.S., Ph.D.

General Physiology

1. Daily measurements of basal metabolism, body temperature and pulse rate during a journey to the tropics.

(Miss) Eleanor D. Mason, Madras.

On a journey from San Francisco to India a woman whose basal metabolism was known to be 10% lower in the tropics (Madras) than in temperate climate (New York and Boston) was measured daily with the purpose of finding out how long an exposure to the tropics was necessary for this adaptation in heat production to be established. The measurements were made before rising in the morning, with a Benedict-Roth metabolism apparatus. The conditions throughout the journey were approximately uniform with respect to diet and activity and the transition from comfortably cool to hot humid tropical climate was abrupt.

On the first two days after exposure to tropical heat both the basal metabolism and oral temperature rose slightly. From the third day the metabolism began to fall and at the end of a week in the tropics was 10% lower than the average rate for this subject in temperate climate. During the second week it fluctuated and fell slightly more. The oral temperature did not return to this subject's normal until the end of the second week and it is suggested that the second week was a period of stabilization of the heat balance.

2. The relation between gastric secretion and hunger contractions.

S. A. Rahman *and* R. N. Abhyankar, Hyderabad (Deccan).

Studies of gastric motility and secretion in man were made simultaneously with two tubes introduced into the stomach. To one of the tubes a thin rubber balloon was attached by means of which graphs of gastric motility were obtained while the gastric juice was aspirated through the other tube. The phase of gastric hunger contractions was usually found to be associated with increased acid secretion. These experiments confirm, on the whole, the observations of Hellebrandt that the motility and the secretory phases of gastric function augment and subside in unison.

Special Physiology

3. Food value by chemical methods of another batch of edibles.*

K. Mitra *and* H. C. Mittra, Patna.

Two kinds of grain foods, 7 kinds of flesh foods, 5 kinds of fruits, 9 kinds of mushrooms, 9 kinds of miscellaneous food, 5 kinds of leafy

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* Carried out under Nutrition Scheme, Bihar, Public Health Laboratories, Patna.

vegetables and 2 kinds of milk products, in all 39 kinds of foods have been analyzed chemically as to their respective protein, fat, carbohydrate, moisture, ash, calcium and phosphorus content. The protein content of the 9 kinds of edible mushrooms varied between 2 to 7%. Meat of mussel and immature prawns gave high calcium figures. The list of foods include, amongst others, meat of field rat and bull frog and white ants which were listed as 'food consumed' during dietary survey operations in certain section of population in Bihar.

4. Estimation of the biological value of common pulses in human subjects.*

K. Mitra and S. K. Verma, Patna.

Biological value of four common pulses, e.g. red gram (*Cajanus indicus*), lentil (*Lens esculenta*), Bengal gram (*Cicer arietinum*) and green gram (*Phaseolus radiatus*) has been studied in human subjects by the balance sheet method. The pulses were fed at 4·5 to 5% level of protein intake. The endogenous metabolism figures were obtained after a six day period of feeding on 'low nitrogen diet' yielding 0·3 to 0·5 gm. of nitrogen per subject per day. The test diets were given for periods of six days in the case of each pulse grain. The urine and faeces collected during the last three days in each period were used for calculation of the data. The average biological value based on four subjects was found to be 89·3 in the case of red gram, 86·2 in the case of Bengal gram, 84·2 in the case of lentil and 82·8 in the case of green gram.

5. The food habits of the Muslims of Bihar and the nutritional state of their children.†

K. Mitra, Patna.

A dietary survey of 709 Muslim families of different economic and social groups consisting of 4,879 persons was carried out in the province of Bihar during the years 1939 to 1943. With the increase in income the consumption of pulses, fats and oils, flesh food, non-leafy vegetables and milk and milk products increased but the consumption of an important protective food, leafy vegetable remained unaffected. The consumption of milk and vegetables was not satisfactory even in the highest income group with an average income of slightly more than one rupee per consumption-unit-man-value per day. This can be definitely ascribed to ignorance of healthy food habits. Even in the higher income groups barely one out of twelve children was rated as 'good' by clinical examination.

6. Vitamin B_1 nutrition in Bihar.

K. P. Bhattacharya and M. N. Rudra, Patna.

Normal vitamin B_1 nutrition in Bihar has been investigated by determining the total excretion of vitamin B_1 in the twenty-four hour sample of urine by a method using Prebluda and McCollum's reagent. The values obtained compare well with the values recently reported in America.

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* An enquiry under the Indian Research Fund Association carried out under Nutrition Scheme, Bihar, Public Health Laboratories, Patna.

† Carried out under Nutrition Scheme, Bihar, Public Health Laboratories, Patna.

7. Rôle of manganese in the biological synthesis of ascorbic acid.*

M. N. RUDRA, Patna.

Rabbits and rats kept on a basal manganese-free diet synthesize and excrete a greater amount of ascorbic acid when they are supplemented with manganese. An explanation of the increased synthesis of ascorbic acid by rats, under certain conditions, first observed in King's Laboratory, has been offered and its correlation with the present observation established.

8. The effect of vitamin C on the glycogen content of the liver of guinea-pigs.

SACHCHIDANANDA BANERJEE, Calcutta.

The glycogen and ascorbic acid contents of the liver have been estimated in scorbutic guinea-pigs, in guinea-pigs on normal diet, in guinea-pigs on normal diet receiving injections of vitamin C, in partly pancreatectomized guinea-pigs on normal diet, and in partly pancreatectomized guinea-pigs on normal diet receiving injections of vitamin C.

The glycogen content of the liver is greatly diminished in scorbutic guinea-pigs, the value being 20–80 mg. per 100 gm. of liver, the corresponding value in normal guinea-pigs being 540–4,580 mg. The glycogen content of the liver of guinea-pigs receiving vitamin C by injection does not differ significantly from that of guinea-pigs fed with normal diet, which is very rich in vitamin C, indicating that extra vitamin C is not required for the better deposition of liver glycogen. In partly pancreatectomized guinea-pigs receiving no injection of vitamin C it is seen that glycogen value of the liver, which varies from 0–145 mg. per 100 gm. of liver, is more or less comparable to that of scorbutic guinea-pigs. Thus with respect to liver glycogen, partly pancreatectomized guinea-pigs may be fairly compared with the scorbutic guinea-pigs. When the partly pancreatectomized guinea-pigs are given vitamin C by injection better deposition of liver glycogen takes place. The ascorbic acid content of the liver is greatly diminished in both the scorbutic and the partly pancreatectomized guinea-pigs receiving no injections of vitamin C. In the partly pancreatectomized guinea-pigs which receive injections of vitamin C, the ascorbic acid content of the liver is increased like that of normal guinea-pigs given ascorbic acid by injection, the corresponding glycogen values of these two groups of animals, however, are not comparable. The above evidence tends to show the rôle of vitamin C on the deposition of liver glycogen which is greatly disturbed in diabetes mellitus. It is therefore suggested that special attention should be given to the vitamin C nutrition of diabetic patients.

9. The effect of vitamin C on the insulin content of the pancreas of guinea-pigs.

SACHCHIDANANDA BANERJEE, Calcutta.

It has been shown previously (Banerjee, 1943) that deficiency of vitamin C in guinea-pigs leads to a change in the carbohydrate metabolism as judged by (1) the glycosuria, (2) the diabetic type of the glucose tolerance curve, and (3) the depletion of the glycogen content of the liver. It has also been shown that the normal metabolism of carbohydrate is restored after the administration of vitamin C. From the above evidence it has been suggested that the action of vitamin C is similar to that of insulin. In the present investigation the insulin content of the pancreas

* Under the auspices of the Indian Research Fund Association.

of normal and scorbutic guinea-pigs has been studied. It has been observed that the insulin content of the pancreas is markedly diminished in scurvy. The change in the carbohydrate metabolism as observed with scorbutic guinea-pigs is suggested to be due to the diminished insulin content of the pancreas of scorbutic animals.

10. Effect of vitamin C on the chloride content of the blood of guinea-pigs.

SACHCHIDANANDA BANERJEE, Calcutta.

It has been observed by Orten and Devlin (1940) that when partially pancreatectomized diabetic rats and intact rats with a low glucose tolerance are given injections of sodium chloride along with glucose the tolerances shown to glucose are normal. Crabtree and Longwell (1936) have reported that the administration of sodium chloride to rats increases the deposition of glycogen in the liver. We have reported that in scorbutic guinea-pigs and partially pancreatectomized diabetic guinea-pigs there is a change in the carbohydrate metabolism as manifested by (*a*) diminished glucose tolerance, and (*b*) diminished glycogen content of the liver. It is therefore highly probable that the lowered glucose tolerance and the diminished glycogen content of the liver in scorbutic and experimental diabetic guinea-pigs may be due to altered chloride metabolism in these conditions. In the present investigation chloride content of the blood of normal and scorbutic guinea-pigs has been studied. In scorbutic guinea-pigs the blood chloride values varied between 417 and 565 mg. per 100 c.c. In normal animals the blood chloride values varied between 462 and 533 mg. The change in the carbohydrate metabolism observed in scurvy is not therefore due to any defect in the chloride metabolism.

11. On the inactivation of sympathomimetic amines.

U. P. BASU, S. K. GANGULY *and* A. N. BOSE, Calcutta.

Adrenaline and similar other sympathomimetic amines are readily oxidized both *in vitro* and *in vivo* and different theories are being put forward to account for this characteristic change of the above bases. The racemization, the oxidation of the side chain leading finally to an aromatic acid, the conversion of the side chain hydroxy group to the ketonic molecule, the oxidation and/or conjugation in one or more of the phenolic hydroxyl groups, if present, are the factors that might be responsible for the inactivation of the molecule of adrenaline-like compounds. In preparing any pharmacopoeial preparation of adrenaline for parenteral administration, a preservative like chlorobutol and an adjuvant like metabisulphite are being advocated. Using chlorocresol in 0·1% strength it is being noticed that oxidation in the phenolic hydroxyl group can be considerably reduced as ascertained by subsequent estimation of adrenaline activity by phenol reagent. The incorporation of any acidic substance, however, lowers down the *p*H of the solution and thereby promotes the inactivation most probably by racemization. Better activity of these groups of compounds may be retained by controlling the *p*H of the solution which should not come down lower than 1·8. Chlorocresol is being found to promote the oxidation of the molecule more than chlorobutol. Further work is in progress to search for a protective agent that might inhibit the oxidation of amine part but at the same time retains the activity of adrenaline like compound in general.

12. Peptone for parenteral therapy.

N. RAY, J. K. GHOSH *and* U. P. BASU, Calcutta.

For the development of body immunity a non-specific protein therapy is often advocated. Either bacterial proteins or non-bacterial proteins,

like milk, peptone, are often used. Nothing about the chemistry of peptone suitable for any parenteral therapy is yet definitely known. Peptone as available in the market, contains various degradation products of protein molecule. In this laboratory an experiment has now been undertaken for the isolation of a peptone suitable for injection. This preparation consists of primary proteose, secondary proteose, peptides and amino acids. Pharmacological investigations show that mice tolerate 225 mg. per 100 gm. given intravenously in a 20% solution without producing any signs of shock. These, however, appeared with a dose of 250 mg. per 100 gm. Certainly lethal dose is being found to be 400 mg. per 100 gm. of the body weight. It produces no irritation when injected subcutaneously or intramuscularly. It is free from histamine as seen by the dermal scratch test. Leucocytopeptic action was tested in rabbits and it is found to give a very fine response in exciting the increase of leucocytes.

13. Influence of vitamin B_1 on the production of glucuronic acid in liver for detoxication.

N. M. Basu, Calcutta.

A more deleterious effect of CCl_4 on fatty liver than on liver filled with glycogen leads one to the conclusion that glycogen is the source of glucuronic acid which detoxicates CCl_4. Glucuronic acid is an oxidation product of glucose, the terminal CH_2OH of the latter being oxidized to COOH. It is surmised that vitamin B_1 or riboflavin or both which are stored in liver and which are necessary for oxidation of carbohydrates may have some rôle in the production of glucuronic acid. The possible influence of vitamin B_1 has been investigated as follows:—

The excretion of total glucuronic acid was estimated in the urine (1) of normal and vitamin B_1-deficient animals, (2) of these groups of animals after the intake of a single dose of CCl_4 (0·175 c.c. per rat) by each rat followed on the next day by the intake of a single dose of chloral hydrate * (200 mg. per kg. of body-weight), (3) of these animals after the intake of a single dose of CCl_4 followed after five days by an intake of a single dose of chloral hydrate, and (4) of these animals after each of them received for a week a dose of CCl_4 per day and then during the next week a dose of chloral hydrate. The results of estimation of total glucuronic acid in the urine show (1) that in the first series of experiments there is a small but definite difference between normal and B_1-deficient animals, the latter excreting a lower amount of glucuronic acid, (2) that in the second and third series of experiments this difference is not appreciable and does not always exist, and (3) that in the fourth series of experiments this difference is appreciable, B_1-deficient animals always excreting a lower amount.

It is concluded that Vitamin B_1 has a rôle in the production of glucuronic acid in liver, but it is evident that its production is controlled by other factors as well, for in B_1-avitaminosed animals an appreciable amount of glucuronic acid is still excreted after the intake of chloral hydrate.

14. Studies on the mineral requirements of bullocks for maintenance.

Narain Das Kehar and S. A. Qureshi, Izatnagar.

The maintenance requirement of minerals of animals is of fundamental significance in formulating balanced rations. It has been pointed out (Chatterjee, 1940) that the nature and composition of the diet exerts a profound influence on the assimilations of Ca and possibly other minerals.

* The administration of chloral hydrate stimulates the production of glucuronic acid and that of CCl_4 causes damage to liver tissue.

This article presents observations on the Ca, P and Mg requirement of Kumaoni (hill) and country (plain) breeds when wheat straw and mustard cake (the commonly available cattle feeds in Northern India) are fed.

It has been observed that (1) the maintenance requirement of Kumaonese and country bullocks were 12-13 and 16-17 gm. of CaO and 9–11 and 11-12 gm. of P_2O_5 respectively; (2) the ration contained more MgO than the required quantity.

Nitrogen balance studies were also conducted simultaneously.

15. Studies on the efficiency of Indian feed proteins for maintenance. Part I. Wheat *bhusa* and mustard cake.

NARAIN DAS KEHAR *and* R. MUKHERJEE, Izatnagar.

Seven adult bullocks were fed on rations consisting of wheat *bhusa, ad lib.*, and graded doses of mustard cake until nitrogen balance was nearly reached. The data which showed only small positive or small negative nitrogen balance have been used for calculating the protein requirement of bullocks for maintenance on the combined feed. It was found that the requirement is about 0·37μ of digestible protein or 0·87μ crude protein per 1,000 lb. body-weight.

16. Riboflavin and pyridoxin (vitamin B_6) as growth-promoting factors for rice moth larva (*Corcyra cephalonica* St.).

P. S. SARMA, Coonoor.

The rice moth larva (*Corcyra cephalonica* St.) requires riboflavin and pyridoxin (vitamin B_6) for its growth. It apparently does not need nicotinic acid and pantothenic acid. The growth of riboflavin-deficient larvae was proportional to the amount of riboflavin added to the diet up to 1·2 μg. per g. of diet. Larger amounts of riboflavin did not accelerate growth. Rice moth larvae can be used for the estimation of riboflavin in foodstuffs and biological materials.

17. The effect of 'exercise' on the pyruvic acid content of normal and vitamin B_1-deficient rice moth larvae (*Corcyra cephalonica* St.).

P. S. SARMA, Coonoor.

When the rice moth larvae (*Corcyra cephalonica* St.) are fed on a vitamin B_1-deficient diet, they accumulate pyruvic acid like man and laboratory animals. This disappears on the inclusion of the vitamin in the diet. An increase was observed in the pyruvic acid content of normal and thiamin-deficient larvae, subjected to a period of strenuous 'exercise'. The highest pyruvic acid values were found in larvae tested three minutes after 'exercise'. The time taken for pyruvic acid values to return to the original level was three hours and was substantially the same in normal and thiamin-deficient larvae.

18. Observations on alcohol and other dichromate reducing substances of blood.

K. N. BAGCHI *and* H. D. GANGULI, Calcutta.

By determining the quantity of alcohol present in the blood, it is possible to calculate the amount of alcohol consumed by an individual. The method usually adopted for estimation of alcohol in the blood is of Southgate (*B.M.J.*, 1926) which involves volatilization of alcohol from

the blood by heat and its oxidation by treatment with standard $K_2Cr_2O_7$ solution and H_2SO_4. The oxidation of alcohol is accompanied by reduction of the corresponding amount of dichromate from which the amount of alcohol is calculated. Any volatile oxidizable substance present in blood, e.g. acetone bodies, if not removed from alcohol, will therefore be oxidized along with alcohol and be liable to be included in the result and expressed as alcohol.

As ethyl alcohol is normally present in the blood to the extent of 4 mg. per 100 gm. of blood (Sollmann, 1939) and acetone bodies to the extent of 1 mg., it is essential to find out definitely the 'normal value', that is, the value for these dichromate reducing substances present normally in the blood of the teetotallers, because this value requires to be deducted from the figure obtained from the blood taken from persons charged of drunkenness.

Thirty-one samples of such normal blood were examined, of which 25 samples, or 80% gave figures varying from 0 to 2·87 mg. In only one case, it was 11·5 mg. and the average of this series was 2·84 mg. per 100 c.c. of blood. In a series of cases recorded by a German worker (Smith and Gloister, 1939) the maximum was 20 and the average was 3·7 mg.

In diabetic subjects the presence of acetone bodies in the blood gives high figures—may be 40 mg. or more.

As alcohol vapour, like ether or chloroform, is very readily absorbed through the respiratory system, persons working in an atmosphere charged with vapours of alcohol, as for instance, in the Excise Section of the laboratory of the Chemical Examiner where analysis of about 11,000 samples of wines, spirits, tinctures, etc. is carried out annually are likely to imbibe alcohol to an appreciable amount. Blood of 12 chemists and assistants (all teetotallers) working in this laboratory was examined and found to contain alcohol varying from 4·6 to 11·5—the average being 7·5 mg. A chemist, who had no alcohol in his blood, imbibed 4·6 mg. of alcohol per 100 c.c. of his blood after working there for about three hours.

7·5 mg. of alcohol in 100 c.c. of blood, the average of this series, is equivalent to about 1¾ drachms of brandy administered by the mouth (Evans and Jones, 1929). The question of administration of alcohol as a stimulant through the respiratory tract in people who do not take alcohol even as a therapeutic measure may be considered on the basis of this finding.

Pharmacology

19. Determination of toxicity of urea stibamine (a kala-azar remedy containing pentavalent antimony) on pigeons.

N. K. DUTT *and* B. MUKERJI, Calcutta.

Urea stibamine, a potent chemotherapeutic remedy administered by the intravenous route, is standardized by the estimation of its (1) antimony content, and (2) toxicity on I.V. injection in white mice. To counteract the difficulty of securing white mice of suitable weight in sufficient numbers, an alternative method of determination of toxicity on domestic pigeons, which are more easily available, was attempted.

Birds weighing between 150 to 250 gm. were selected and kept under laboratory diet for seven days. Food was withdrawn 20 hours before injections were given (a 4% sol. of urea stibamine was used) in the wing veins. The pigeons were observed for a period of 7 days after injection, any death occurring during the period being considered due to the toxic effect of the drug. Preliminary observations on 100 birds indicate that pigeons may be safely used for the 'toxicity' determinations. The M.T.D. is approximately 225 mg. per kg. and the M.L.D. 50 (Karber's method) about 300 mg./kg. A statistical analysis of the data is in progress.

20. Estimation of the diuresis-inhibiting activity of pituitary (post) extracts.

B. N. CHOWDHURY, N. K. DUTT *and* B. MUKERJI, Calcutta.

The antidiuretic activity was determined by a combination of methods enunciated by Gibbs and by Burn. Sixteen male rats in groups of four were used in each experiment. Sterile warm water (10 c.c. in each rat) was injected intraperitoneally and pituitary extract subcutaneously, and maximum excretion time of urine determined in injected animals. A standard dose-excretion curve has been constructed from observations on 100 rats, keeping a control with International Standard Post-pituitary extract. The maximum excretion time is found to be on the lower side (107 mins. to 125 mins. for doses between 0·004–0·008 units per 100 gm. body weight of rat) compared to the figures given by Burn (140–166 mins. for doses between 0·004 to 0·008 units/100 gm.) but there is good correlation between this data and the data obtained by the oxytocic method of assay, the average percentage variation in potency estimation being of the order of 15·2%.

21. Effect of transfusion of serum, plasma and dried serum in 'bled' cats.

N. K. DUTT, B. N. CHOWDHURY *and* B. MUKERJI, Calcutta.

To evaluate the relative resuscitation properties of blood substitutes recently introduced into medicine, artificial hemorrhagic shock, similar to that produced in field wounds and severe accidents or burns, was produced in healthy anaesthetized cats by bleeding from the carotid artery until the blood pressures of the animals were reduced to 50 mm. Hg or even lower from their original levels of 130–150 mm. Hg. Transfusions of the blood substitutes were given via the femoral vein at a regular controlled rate, the amount transfused not exceeding the amount of blood withdrawn through the carotids. Artificial respiration at a constant rate sufficient to maintain the activity of the respiratory centre was given.

Experiments were performed with 41 samples of sterile liquid serum, 8 samples of liquid plasma, 3 samples of dried (lyophilized) plasma and one sample of dried serum obtained from the 'Blood Bank' of the All India Institute of Hygiene. Following transfusion, it was observed that in certain instances, instead of counteracting the shock and elevating the blood pressure to more or less its pre-hemorrhagic level and maintaining it at that level, a definite depressor response was elicited, resulting in the death of the experimental animal in the majority of cases. This reaction is definitely not due to a heterologous (human) serum or plasma being transfused into cats, as cat's serum processed under identical conditions also produced the same reaction. Reaction was elicited from serum obtained from collected blood kept in a high temperature (room temperature in summer) for more than 10 hours, as well as from serum kept (before processing) in contact with the clot for more than 72 hours. The problem is being further investigated.

22. Investigations on the galactagogue nature of the Indian cress seeds.

M. B. SAHASRABUDHE, Bangalore.

Indian cress (*Lepidium sativum* Linn.) is reputed to have emmenogogue and galactagogue properties. In view of the voluminous literature regarding the antagonistic nature of the estrogens and the lactogenic hormones, the co-existence of the two principles in the same seed is very interesting. A detailed biochemical and pharmacological investigation was therefore undertaken by the author. In continuation of the estrogen

therapy experiments published earlier (*Current Science*, **12**, 23, 1943) the galactagogue property of the seed was investigated and confirmed by employing Dagg's technique for studying lactation with some modifications. The author explains the co-existence on the assumption that the estrogens actually stimulate increased secretion of prolactin by the pituitary. Further work in the line is in progress.

SECTION OF PSYCHOLOGY AND EDUCATIONAL SCIENCE

President:—JOHN SARGENT, C.I.E.

General

1. Studies in race-mind. I. Race-mind seen in its higher achievements.

N. N. SEN GUPTA, Lucknow.

The cultural products of a people supply a measure of its mental ability. The number of eminent men who excel in the arts and sciences, religion and state-craft, gives a fair measure of a race's ability. The relative frequency of eminent men among different peoples and the direction of their labour, then, indicate the capacities of a race and the direction of its ability. The paper presents an evaluation of different races on this basis.

2. Studies in race-mind. II. Race-mind as seen in its sensory-traits and reaction-times.

N. N. SEN GUPTA, Lucknow.

Sensory-traits and reaction-times have a high correlation-value with intelligence. The latter again bear a high correlation with the principal mental capacities. A study of sensory-capacities and reaction-times is likely to reveal the level of mind that a race has. This paper gives an analysis of studies of this nature and indicates the limitations of the method.

3. Studies in race-mind. III. Crime, suicide and insanity as indices of race-mind.

N. N. SEN GUPTA, Lucknow.

The race-mind is measured by its successes no less than by its failures. The frequency of aberrations is a fair index of the dark-spots that lurk behind a bright *facade*. The paper gives an analysis of statistics of crimes and other aberrations of several of the races and attempts at an estimate of this method of study.

4. Orientation in psychology.

P. S. NAIDU, Allahabad.

Text-books in psychology in current usage are woefully lacking in orientation. One is not able to see the thread of unity running through the various topics discussed in these books. No two books follow the same order of treatment, and sometimes in subsequent editions of the same book the order is changed. A scientific book should not suffer from this the most serious and the most unscientific of defects. What is the root cause of this disorganization in psychology? It is the lack of a single unified psychological theory of human nature. The existence of diverse, and perhaps rival, schools of psychology is, in the main, responsible for

this trouble in our science. But, there is also another reason, and that is the pernicious influence of that 'great' psychologist who ridiculed experiment in psychology, William James. We have shown in this paper how this defect may be set right through the introduction of the orienting principle offered to us by hormic psychology. An organized scheme for the treatment of psychological topics is suggested, and this is illustrated by two diagrams. Orientation in psychology is possible only through the introduction of the concept of Purpose in our study of human and animal behaviour.

5. A study in binocular equilibrium.

ANIL KUMAR BANERJEE, Lucknow.

A study of sixty readings, obtained from a series of experiments with ten subjects under laboratory conditions, shows that the phenomenon of binocular equilibrium does not obey any definite principle of time-relation. Like all other muscular adjustments it shows an improvement after a few trials at the beginning. The phenomenon indicates effects of practice and fatigue.

6. Psycho-music in war and after.

(MRS.) BANI CHATTERJI, Calcutta.

As pertaining to the human mind, music has a rôle in the field of psychology. Sympathy, which music treats of, is instinctive in man. Under the inspiring guidance of music and its humanizing influences this sympathy rises to great heights. Like psychology, music is pertaining to education and recreation of the mind. Music acts as a safety valve to the suppressed emotions and may thus help to find a solution to 'the problem behaviour'. Mental defects, such as the war-neuroses, etc., may be remedied by the combined efforts of psychology and music. Evidences of such cures by the art of music are not rare. For the sake of the suffering humanity, for the salvation of its mentally disabled, the conjoint study of psychology and music is urgently desirable. Incidentally, in their union a new science would be in the making—'*The Psycho-musical Science*'.

This new science, which needs a thoroughly intensive and exhaustive trial, might help in the cure of the war-affected 'mental-wrecks'.

7. Growth of meaning-experience in 'primitive' mind. A psychological theory.

KALI PRASAD, Lucknow.

The primitive mind develops its reactions mainly under sense-imaginal dominance and meaning would appear to be characterized by 'over-determination by image'. It bears resemblance to an 'eidetic' pattern. But the meaning-pattern is many-dimensional.

This does not mean that primitive mind is a mosaic of distinct qualities nor an 'arrested' growth, but a dynamic pattern in which lesser wholes are integrated in larger wholes as in *gestalten*. Psychologically, meaning then is a function of 'transubstantiation' of levels of experience, and physiologically of irradiation of impulses, and correlates to the general central facilitation of the nervous system as a whole.

8. Growth of meaning-experience in animal behaviour: A psychological theory.

KALI PRASAD, Lucknow.

1. Some biological fictions about animal mind, e.g. 'wholes', 'end determines the means', etc.

2. Consciousness *not* necessary for meaningful behaviour in animals (or in man).

3. Categories of animal mind: (i) Simple co-ordinations, and invariable co-ordinations or stereotypy (as in lower organisms); (ii) Imitation (as in monkeys and apes); (iii) Simple deductions and conditioning; (iv) 'Irreversibility'; (v) Impulsiveness; (vi) Sensory and perceptual dominance; (vii) Poor range of memory.

4. As in our case, meanings develop in animal mind by the progressive development of gestalt. Animal responses are *pattern-responses*. The behaviour of micro-organisms, wasps, bees, ants and other animals (like monkeys and apes) represents a progressive development pattern-reactions much as in our own.

9. Influence of letter position on visual apprehension.

UDAI BHANU, Indore.

This paper opens with the question of position of stimulus on visual apprehension and physiological changes in the cerebral cortex, if any. Actual experiments were carried with eight homogeneous coloured letters with the following results: (*a*) In visual apprehension the letter position has a definite effect; (*b*) from left to right there is a constant and gradual decrease in reproduction till the seventh position of the letter; (*c*) there are rapid drops in score from the fourth to seventh position; (*d*) the average span of visual apprehension is four letters; (*e*) the influence of sex and method is clearly seen; (*f*) there is always an increase at the eighth position; (*g*) the scores of the subject are higher in groups.

10. 'Liking thought' versus 'liking people'.

RAJ NARAIN, Lucknow.

Psychologists are wont to assume an antagonism between *liking thought* and *liking people*. The present paper seeks to verify this assumption by repeating the experiment of Abernethy with two groups of post-graduate students. It was found that there is a positive but low correlation between *liking thought* and *liking people*. The results as found do not tally with those of Abernethy which may be due to the small sample tested by the author. In any case, the antagonism between *liking thought* and *liking people* seems to rest on very uncertain foundations.

11. Gestalting in children.

N. S. N. SASTRY, Mysore.

Organizing the percept, whether purposeful or not, is a characteristic of the mind. It early reveals itself in the working of the child mind.

The problem was to find out at what age generally, gestalting takes place in children, with reference to certain kinds of materials. Separate drawings of eyes, mouth, nose and ears of a human face, and a drawing of the whole face are used.

The average age at which children are able to recognize these features in the face but not when isolated, seems to be two years and a half. There are individual differences.

These differences are attributable to innate intelligence. Factors like home-condition are also considered with regard to their bearing upon gestalting.

12. The emergence of natural muscular rhythm.

(MISS) PRITI KANJILAL, Lucknow.

Rhythm is a movement in equal intervals. Besides the organic rhythm movement, the study of the normal rhythm movement has been

quoted from various sources. Rhythm works on children's education, activity, etc., too. Here this paper deals with the question whether movement at a maximal speed disturbs movements in groups. Experiments made on subjects show that rhythm varies in character, frequency, time, number of breaks, etc. Result shows that rhythm emerges in all cases, sometimes immediate and sometimes delayed, with a marked individual difference of dominant rhythmic type although fatigue influences the rhythm at times.

13. Aristotle's illusion.

K. C. MUKHERJI, Dacca.

Aristotle's well-known experiment shows that when the index and the middle finger are crossed and an object is held between the finger tips, there is an illusory sensation of touching two objects. This illusion is so strong that it does not vanish even when controlled by sight, and it increases if the object is rolled between the fingers. The converse observation is made by Rivers. A subjective feeling of three touches is reported by some subjects when the ulnar side of the index and the radial side of the middle finger, as crossed, are simultaneously touched by two rods. Dr. Bose's observation on the allied point is illuminating.

14. Universalization and idealization.

P. T. RAJU, Guntur.

The universal as an average—as an eternal object—as an ideal—the universal and purpose.

The working of the universal in the scientific mind—the universal and the form—the form as subjective and objective—later subjective elaboration of the objective form—forms and harmonies.

15. Quantitative mental estimate of brightness values.

S. C. MITRA *and* ANATHNATH DATTA, Calcutta.

This paper presents the data of an experiment carried out in the Psychological Laboratory, Calcutta University, on mental estimation of brightness values. Before an uniform background were placed two paper discs—one white and one black. On another colour mixer placed between the two discs, different shades of grey were presented to the subjects. Considering the black to be zero and the white to be 50, the subjects were asked to assign a mark ranging between 0 and 50 to the shades of grey presented to them. The results have been statistically treated and a comparison has been made between the results obtained and those of similar experiments on colour estimation reported in the *British Journal of Psychology*.

16. An experimental study of errors in immediate inferences.

D. RAMAKRISHNAIAH, Guntur.

Many tests in 'Immediate Inferences' were framed and administered to large groups of Logic and non-Logic (science) students. The subjects were asked to say whether the suggested conclusions followed necessarily from the given premises.

The tests are designed to study quantitatively the causative factors underlying the differential reaction to false suggestions.

On administering the tests, the results showed the following conclusions:—

(*a*) Logic and non-Logic students commit nearly same number of errors; (*b*) invalid immediate inferences produce more errors

than the valid; (*c*) in invalid 'immediate inferences', *bias for* the acceptance of the suggested conclusion causes about $3\frac{1}{2}$ to 4 times the errors as *bias against*. In valid 'Immediate Inferences', *bias against* the acceptance of the suggested conclusion produces about $2\frac{1}{2}$ to 3 times the errors as *bias for*.

Educational

17. A comparative study of group intelligence test-element scores in English and vernacular with a note upon the 'practice-effect'.

S. JALOTA, Jullundhar.

This paper reports the comparative figures for the test-element scores. Of late, a number of other workers have published similar comparative figures with single test-elements. The writer reported at the 1939 session results obtained by comparing the total scores of a battery of group-tests conducted in English with similar tests in Hindi and Urdu. This paper refers to the following elements: Instructions, Number series, Memory, Classification, Best answers, Analogies, Cancellation, Logical selection and Reasoning.

Time and score norms with 'maximum scores and their frequency' are also given to help others in devising similar test-elements.

There is further discussion of the 'practice-effect', in continuation of the paper already published in the *Indian Journal of Psychology*, 1937. Some interesting methods have been devised and the results are discussed in this paper.

18. Language of the text-books and language in daily use.

B. KUPPUSAWMY, Mysore.

There is now a great gap between the spoken language and the language of the text-books. Consequently, the spread of education is very slow. The elementary school children as well as the adults who pick up the art of reading and writing lapse into illiteracy soon. The essential principle in the expansion of literacy among the masses is imparting information and knowledge through the language in daily use among children and adults. The method of implementing this principle is the preparation of basic word lists in each language in the country. Committees of educational experts who have training in experimental work must be set up in each linguistic zone to prepare a list of words actually spoken by the children and the illiterate adults. The books should be written only using such words. This scheme is bound to accelerate the expansion of elementary education as well as adult education in an unprecedented way.

19. Distribution of learning ability among ten generations of rats.

B. KUPPUSAWMY, Mysore.

Ten generations of white rats were given a water maze to learn. The distribution of the learning ability is according to normal probability. It was found that the average ability tends to remain constant from group to group. The proportions of superior and average rats also tend to remain constant. These results show that the old notion that the general ability or intelligence is a unit factor, dependent on a single gene is incorrect. General ability is not a quality which is present or absent like colour or form of hair. It is a continuous quantitative variable.

20. A comparative study of the performances of arts and science graduates in the B.T. examination of the Dacca University.

HEM CHANDRA BANERJEE, Dacca.

An examination of the results of all arts and science graduates in different subjects of the B.T. degree examination of the University of Dacca for a period of four years, from 1940–43, shows that except in Educational Psychology, History of Education and General English, where the differences are not very great, the science graduates, on the whole, did better both in the theoretical and practical part of the examination. The science graduates gaining first class diplomas are 19·1% compared with 13·1% of the arts graduates. An examination of the results shows also that honours graduates or graduates with the Master's degree (both in arts and sciences) secured high percentages of first class diplomas. The failures in the B.T. examination as a whole are 9·3% of the arts graduates and only 3% of the science graduates.

21. Nature of intelligence and its measurement.

G. BOSE, Calcutta.

It has been said that intelligence is that which the intelligence test measures. This statement which has found wide currency has been responsible for great deal of confusion in the field of measurement of intelligence. It is futile to devise intelligence test without some idea of the nature of intelligence. A mathematical concept of intelligence, such as an entity with two factors or one with multiple factors, is of no use to the psychologists. An attempt is made in this paper to indicate the nature of intelligence and the general principles which should be observed in devising tests for its measurement.

22. Need for sex instructions in schools.

RABI GHOSH, Calcutta.

A case is here presented where it can be definitely asserted that opportunities for sex instruction would have averted the troubles as were encountered in the case. The case is that of a girls' school in a big city. Psychologically it is very difficult to impart sex knowledge, however practically it may be felt as a need.

Abnormal

23. Multiple personality.

P. S. NAIDU, Allahabad.

I had a rare opportunity for studying at first hand a most remarkable case of quadruple personality. A boy in his sixteenth year developed three different personalities in addition to his normal self. This normal self (P1) disappeared completely for about two years, its place being taken at different times by that of a Greek goddess (P2), a South Indian demon (P3), and a nebulous personality (P4) which lasted throughout the period of abnormality. The outstanding features of behaviour of these personalities are described in this paper. The causes for the dissociation are discussed, and it is shown, in a general way, that the facts observed fit into the Freudian scheme. But the cure was effected in a very striking and painful manner through the evocation of fear. This cure is discussed, and it is shown how from this point of view, the McDougallian theory of dissociation is more satisfactory. Freud and McDougall, therefore, should be synthesized, and the sooner the synthesis is brought about the better it will be for psychology.

24. Psychological effect of deafness and possible means of its alleviation.

KALIDAS BHATTACHARJEE, New Delhi.

Since temporary illness can act upon a psychological phenomenon, therefore the deaf with permanent disability would resort to morbidity and petulence. The invisible struggle of the deaf hits hard in their life process, even more than blindness.

In all associative activities of life from the very infancy till the end of their days, the deaf, on account of loss of hearing and lack of language, lag far behind the normals. A shun grows up between the two distinct communities—the hearing and the deaf. This isolation shatters their mental growth and an insurmountable inferiority complex becomes ingrained in them. They are thus compelled to live a secluded melancholic life.

The scientific education in the West has greatly eradicated the morbid mental state of the deaf. For their alleviation, adoption of such a profitable scheme should be thought of and the Science Congress has a call to deal in the subject.

25. Work curve of criminals.

RAJ NARAIN, Lucknow.

A criminal is defined for the purpose of this paper as one who has been convicted by Courts of Justice. Data for work curve of 20 such criminals were obtained by noting their progress in blanket-weaving from hour to hour and from day to day for six consecutive days. It was found that the average (weighted) output per hour of all the *S*'s rose steadily in the morning spell, reached the highest peak of efficiency between 12 noon and 1 p.m. (immediately after rest), fell a little (1–2 p.m.), reached another high level of efficiency (2–3 p.m.) to fall towards the end of the day. The average (weighted) output for the afternoon spell was considerably higher than that for the morning spell. Computation of coefficients of correlation between age, term of imprisonment, term spent in jail, and days of practice in the task and average total output per day showed no existence of relationship between them.

26. Sex differences, 1930–1941.

RAJ NARAIN, Lucknow.

The present report on sex differences is based on material found in psychological journals, in particular the *Psychological Abstracts*. Findings are analyzed with respect to (i) ability or trait investigated, (ii) number and nature of *S*'s tested, (iii) method or test applied, and (iv) results obtained, and grouped under suitable heads like Personality, Interests, Intelligence, etc. in a tabular form. In this the report differs from the reviews of the subject published in the *Psychological Bulletin*. It is hoped that the report will meet a real need of the students of psychology and education for an analytic, up-to-date and descriptive summary of our knowledge of sex differences.

27. The psychology of errors in speech.

K. D. GHOSE, Dacca.

Mistakes in speech, writing, etc. are very common even without illness. Forgetfulness is neither uncommon. The psychological basis of these mistakes carry a meaning. This paper deals with mistakes in speech in particular. Various physical and psychological factors produce slips. The limitations of the 'attention' theory. Slips also occur when the

attention is concentrated even. Psycho-analysis furnishes the right answer for these mistakes. Examples collected by the writer would leave very little doubt that the mistakes made by perfectly normal healthy people have a definite meaning. The matter becomes one of psychological investigation, with very little reference to physiological and psycho-physiological conditions. The technique of slips well known to poets and playwrights also. Other types of errors where the meaning is not plainly observed can be found out on a very close inspection—they are not mere accidents but have a definite meaning and born generally out of a conflict of two different intentions.

28. Symbolism in Hindu gods.

N. S. N. Sastry, Mysore.

Dreams of individuals and dreams of a people are strikingly similar. Both reveal characteristic working of the mind. Myths, legends and folk-lore may be taken to be the dreams that the primitive men dreamt, where the Collective Unconscious revealed itself.

Complexes of the people are revealed in such compositions. Oedipus complex is universal. Different people have expressed it in different compositions. The story of Ganesha—the Hindu god—is an example.

Conquest of the primitive culture by civilization, specially in India, took over the contents of the former into it in a sublimated form. The deified primitive gods are examples here.

Stories of gods and goddesses can reveal the conflicts, etc. in the mind of the people which created them.

29. The rôle of Oedipus complex in the psychogenesis of epilepsy

I. Latif, Lahore.

The case-history of two patients is presented to show that their epileptic seizures were mainly determined by their hostility against their parents.

30. The psychogenesis of manic-depressive psychosis.

I. Latif, Lahore.

Four individual cases are presented to show that in each instance the patient's hostile impulses directed against the outside world were gradually introjected within himself.

31. The psychological significance of constipation in cases of patients suffering from depression.

I. Latif, Lahore.

An attempt is made to explain the nature and meaning of stubborn constipation in the case of patients suffering from depression. The case of three patients is presented and analyzed.

Vocational

32. Need for personnel research in India.

S. N. Roy, Calcutta.

Economical prosperity, industrial development, agricultural research, etc. figure prominently in all plannings and suggestions regarding national advancement of India. Exploring the raw materials scattered in abundance in India and systematic research for thorough and proper

utilization of them are considered, of course with justification, as important factors. Unfortunately, the aspect of human materials—an enormous figure of 400 millions—and the question of scientific research for right use of them, receives nobody's due attention. A plea for personnel research in India—its utility and importance recognized all over the world. Personnel research is an important item in present-day war efforts in Western countries—organizations in India engaged in personnel research work. Its usefulness is to be increasingly felt after the war when industrialization is expected to have its sway in India. Any post-war social reconstruction scheme will be incomplete if researches in personnel problems are not included in its curriculum. (Plan suggested for undertaking personnel research work in India.)

33. Two motive-patterns in vocations.

RABI GHOSH, Calcutta.

Two patterns of vocational motivations are discussed in this paper. These patterns give rise to two types of character easily recognized. In one, an earlier rebellious attitude towards the father or the father-equivalents is found contrasting very clearly to an ardent devoted attitude towards the chosen profession. In the other, a very light-hearted application to rules and regulations of the vocation is very evident; the careerist having committed a mistake expects to be excused; in face of impending dangers he fondly imagines to be rescued or else hopes the disappearance of the danger from the scene. Both types present difficulties when they come up for vocational guidance.

34. On Kelly's constructional ability test.

GAURANGABHUSHAN GHOSH, Calcutta.

The ability to initiate a problem as well as to execute a given task is said to be measured by the Kelley's constructional ability test. This paper attempts to discuss how far Kelly's test really achieves the purpose for which it was devised.

Child and Industrial

35. Psychology of handicraft.

INDRA SEN, Delhi.

The paper argues from the modern psychological conception of human nature and experience how handicraft is a necessary means for the mental growth of the child. Further, it shows the superiority of handicraft as an educational means to the ordinary method of instruction in disciplining fundamental moral qualities. The reason is that manipulation answers better to the needs of child nature.

However, the most important condition on which the success of handicraft as an educational method depends is the attitude and atmosphere in which the work proceeds.

36. Relativity of ideas and notions and the reasoning of children.

T. K. N. MENON, Baroda.

Piaget, the great child psychologist, advances his theory of Ego-centrism to explain children's reasoning. The present writer during 1933–35 investigated the correctness of his theory. This paper deals with one aspect of the investigation, viz. 'Can children between 7 and 9 grasp the relativity of ideas and notions?' If they cannot, as Piaget argues, is the failure due to Ego-centrism?

The tests, as employed by Piaget after being modified to suit local conditions, were administered on 40 children. Applying the 75% success standard of Piaget, the group succeeded in solving all the items in both the tests. Even the incorrect answers did not show traces of Ego-centrism.

The quantitative analysis of the answers lead to the following con-conclusions: (*a*) Indian children between the ages 7 and 9 do not experience any difficulty at all to grasp the relativity of ideas and notions. The age, which Piaget reports, is very high. (*b*) Piaget's claim that inability to grasp the relativity of ideas and notions is one of the chief obstacles to the development of children's reasoning and that this inability is due to Ego-centrism is not supported by the answers obtained in the case of Indian children. (*c*) The order of the stages in the evolution of the child's notion of right and left as formulated by Piaget is different in the case of Indian children.

37. Studies in work-types.

H. S. Asthana, Lucknow.

The paper reports the conclusions of a series of experiments conducted on work-types. Three distinct types were revealed.

The curve termed A-type is short with little warming-up. Very high efficiency is displayed in the beginning and the fall continues from there at a very rapid rate. In about the fourth or fifth period the rapidity of fall slightly decreases.

The B-type curve is longer having a period of warming-up and a period of high efficiency which extends to the middle of the curve, after which the curve assumes the A-type fall.

The C-type curve is unusually long and has definitely a period of warming-up extending sometimes to the second period. It has an efficiency amplitude which is somewhat lower than the B-type. After the maximal efficiency is reached, a slow and gradual fall sets in to continue till about the middle or two-thirds of the total work when the curve assumes a plateau-like form of an extremely low efficiency for the remaining period.

38. Some problems of morale of mill labourers.

Pars Ram, Lahore.

The problem of morale is essentially the problem of adjusting rural population, taking to factory work, to the new mode of life that the factory enforces on them. This can be solved only when manual and mental activities employed in earning livelihood also become a source of joy and recreation to men. At present there is a gulf between the professional and extra-professional activities of workers. The war situation has necessitated production at high speed and has drawn attention to the problem of morale.

Factors which weaken morale are: modes of work and rest of villagers are essentially different from those of the factory workers. Many villagers find it hard to work by the clock for a number of hours at a stretch under supervision. Researches in work and fatigue have made available certain ways and means by which this maladjustment can be removed. Jealousy, lack of professional sense and the lack of informal social contacts in factories work against morale.

Adult education, recreations, wise supervision and professional conferences of workers are some of the means by which morale can be built.

SECTION OF ENGINEERING AND METALLURGY

President:—J. J. Ghandy, C.I.E.

1. Vermiculite.

W. H. Bates, Coonoor.

The author's object in presenting this paper is to urge geologists and others to search for vermiculite ore in India.

Vermiculite is described as being a form of biotite of mica. It is found in the form of small flakes varying from pin head size to about one quarter of an inch in diameter and one line in thickness.

When subjected to a high flame temperature it expands to nineteen times its original size. During this process moisture is expelled from between the numerous flakes and replaced by air, the expanded ore is sufficiently resistant to applied pressure to remain undeformed under a considerable load.

The resistance to pressure is a necessary feature and so far there has been no discovery of an Indian ore which possesses this quality.

The paper describes the insulating and other properties of vermiculite and also the first importation of vermiculite by Messrs. Burn & Co. Ltd. of Calcutta, the patenting of a method of expansion, and the subsequent erection of a modern factory which is now in successful operation.

2. On an improved type of bottle silt sampler.

K. K. Framji *and* G. S. Raisinghani, Karachi.

Gerald Lacey in his 'Stable Channels in Alluvium' defined his new concept of an additional hydraulic variate '*f*' termed by him as 'silt factor' and revised the fundamental flow equations for average silt transporting channels. Different methods and apparatus were, therefore, devised to study the chief quality characteristics of the transported material, particularly the silt charge and silt grade.

The Bottle Silt Sampler was originally designed in 1934 for collecting silt-laden water of channels. The Binkley and Uppal types of silt samplers which came in use subsequently proved to be costly, complicated and cumbersome. It was, however, found essential that unlike the Binkley and Uppal types, the mouth of the bottle sampler should be left open under submergence for the minimum time to fill as otherwise silt concentration increases with longer time interval for which the bottle remains open under submergence.

It was, therefore, necessary to provide an infallible device to know when the bottle gets filled so that its mouth may be closed instantaneously. The bottle sampler has been provided with a make-and-break circuit device so that when the bottle gets full, an electric bell rings and the mouth is stoppered by releasing a spring.

The device has been tried and found to be efficient and useful in the work of silt sampling.

The paper is accompanied with a blue print sketch of the Improved Bottle Silt Sampler and references have been quoted.

3. A new silt size determinative apparatus: silt mechanalyser.

G. S. Raisinghani, Karachi.

Silt analysis in connection with regime flow of channels is indispensable and a large number of silts has to be mechanically analysed with a view to find the '*m*' value for substitution in the Lacey formula. The paper describes an improved and simple method of assessing wetted mean diameter of silts directly and rapidly.

The silt mechanalyser has been devised on the principle of passing air through a silt column and in continuation displacing water from a burette. The volumes of displaced water are correlated with w.m.d.

A sufficient number of silts of known w.m.d. by any accepted method of silt analysis is tested by means of the silt mechanalyser and a siltograph is plotted showing w.m.d. values versus the volumes of displaced water. Knowing therefore the volume of displaced water of an unknown sample with the silt mechanalyser, its w.m.d. can conversely be obtained from the siltograph readily.

The necessary precautions to be taken while working with the silt mechanalyser have been suggested and the further scope of work outlined.

4. Tests on propeller pumps.

S. Rajaraman, Trivandrum.

Propeller pumps are being used to a very large extent in Travancore for dewatering paddy fields in the Vembanad area where the fields are at a level lower than that of the river. The existing pumps are not very efficient and tests have been conducted with various improvements and additions on the full scale pump as well as a dimensionally homogeneous and dynamically similar model. The test results show a marked improvement in efficiency and certain interesting results have been deduced.

5. Centering for R.C.C. slabs.

S. Rajaraman, Trivandrum.

The paper deals with a method of centering for R.C.C. slabs which has been adopted with success by the author during the years 1937–39, in the construction of the Capital Buildings at Koraput in the Province of Orissa.

Rows of posts are arranged on planks with wedges in between. Ledgers are provided over the posts and cross joists are put in over the ledgers. Planks are then placed over the joists and at right angles to them. Sand to a thickness of about 1″ is spread on the plank surface, wetted properly, then plastered with cement mortar and finished smooth. The surface is then oiled. The grill is assembled on the ground, lifted up and placed in position and then the slab concreted in the usual way. When the centering is removed a very smooth surface is obtained on the underside of the slab and by this method of construction no treatment is necessary to the bottom of the slab.

6. On the road of constant slope up a conical hill.

S. Natarajan, Trivandrum.

Geometrically, the problem of constructing a road of constant slope round a conical hill may be reduced to the following:—

Consider a line *OA* drawn from a point *O* and making an angle α with the horizontal plane through *O*. A right circular cone—height h and slant side l—is placed on the horizontal plane so that *OA* is a tangent to it at *O*. If the cone moves such that it is always in contact with *OA* and does not slip on it, it is clear that the trace of *OA* on the cone is a

line of constant gradient on the curved surface. Further, in any position, the plane making an angle $\left(\frac{\pi}{2}-\cos^{-1}\frac{h}{l}\right)$ with the horizontal and passing through OA is tangential to the cone. Thus, the cone may now be looked upon as moving between these two planes such that the base circle rolls without slipping on their line of intersection.

Let the vertex of the cone come on the line OA when the base circle has made k revolutions (k may be integral or fractional). In this position, let A be the vertex, B the point of contact of the base circle with the line on which it rolls and C the centre of the circle. In the figure $OABC$, OB and BC are at right angles, and so also are OC and CA and BC and CA. Further

$$AC = h, \quad AB = l \text{ and } OA = h \operatorname{cosec} \alpha.$$

$$OB = 2k\pi(l^2-h^2)^{\frac{1}{2}} \text{ and } BC = (l^2-h^2)^{\frac{1}{2}}.$$

Hence the length of the trace on the cone is $h.\operatorname{cosec} \alpha$. And the number of revolutions is given by

$$k = \sqrt{(h^2-l^2\sin^2\alpha)/(l^2-h^2)}+2\pi \sin\alpha.$$

Thus the problem of constructing a road of constant slope up a cone follows from very elementary principles of Geometry.

7. Experimental researches regarding causeways with pipe vents in sand foundations.

S. P. RAJU, Hyderabad (Deccan).

Several causeways built by H.E.H. the Nizam's P.W.D. on sand foundations with pipe vents concentrated in the centre were damaged in the rains by deep scours formed at the sides of the ventways and underlining the foundations. The problem was referred by the Chief Engineer and Secretary to Government to the author and through the investigations carried out a great deal of expenditure was saved.

In case of flow through the vents, the scours were due to vertical vortices generated by a strong jet adjacent to still water. When overflowing, it was due to the vertical nappe falling over the sand being broken into two 'rollers', the forward one carrying the sand away and the backward one initially heaping up the sand in the rear but eventually slipping. These scours were eliminated by introducing jets in the still water region.

To reduce the period of submergence and lessen the inconvenience to the traffic, methods were found by experiments to increase the pipe and weir coefficients of the causeway. In order to reduce resistance offered by the guard stones as constructed at present, special streamlined guard stones were designed which have now been standardized in the Hyderabad P.W.D.

8. Raw materials for ferro-alloys industry in India.

BALARAM SEN, Jamshedpur.

In this paper the manufacture of ferro-alloys in India has been advocated and stress is laid on the importance of light metals and their alloys. Raw materials for principal ferro-alloys and their Indian sources are discussed. Possibilities of export trade of ferro-manganese, ferro-silicon, ferro-titanium, ferro-vanadium and ferro-zirconium have been envisaged, but economic methods of extraction of vanadium and titanium from the Indian vanadiferous-titaniferous iron ores must be found to meet post-war competition. Ferro-silicon must play an important part not only for the steel industry but for extracting magnesium from dolomite. Ferro-alloys from Indian chrome, tungsten and phosphatic ores are only

just enough for meeting domestic requirements. For ferro-molybdenum, molybdenum ores must be found in India.

Raw materials for ferro-alloys are mostly available in Northern India. The industry should therefore be established close to the Iron and Steel Works. Muri Station, B.N. Railway, is a suitable site as power can be developed from coal near Barkakana, or from Hundru falls close-by. Raw materials for light metals are also near. Opinion is expressed that the industry may grow on the same lines as at Widnes, England.

9. Refractories for acid Bessemer Converter.

H. K. MITRA, Jamshedpur.

Acid Bessemer Convertors are generally lined with siliceous material—mica schist, firestone and soft fired silica brick. In selecting a siliceous refractory, the emphasis seems to have been on the silicon content of the metal. Resistance against manganese oxide, ferrous oxide, and other service factors which tend to affect lining is important. An analysis of the service factors prevailing inside a converter has been given. From a consideration of these, alumino silicate refractories with high alumina content have been tried on the 'shoulders' in place of mica schist at present used. Nose and gullet have also been lined with other grades of alumino silicate refractories. Data are also given for a trial with a complete brick-lined vessel. Advantages claimed for substitution of mica schist by refractory brick are increased lining life, reduction of 'down time' for converters with consequent increase in steel production.

10. Utilization of zinc wastes of galvanizing plant.

H. P. SAMANTA, Jamshedpur.

A brief review is made as to the various ways of reclaiming zinc wastes of a galvanizing plant, which are in the neighbourhood of 3-4% of the weight of galvanized products. A very good yellow pigment was prepared from zinc ash after completely separating iron from $ZnSO_4$ solution prepared by the action of sulphuric acid. Oxidation of ferrous sulphate was effected with K_2CrO_4 or Na_2CrO_4 with subsequent precipitation of iron as $Fe(OH)_3$ with NaOH. By treating the iron-free $ZnSO_4$ solution with requisite strength of either Na_2CrO_4 or K_2CrO_4 solution, the yellow pigment was precipitated. From 70-75% of ZnO the ash was recovered in one step in the form of pigment from the zinc sulphate solution. The data for recovery are given and the merits and demerits of the pigment are dicussed.

11. The spectro-chemical analysis at Tata Research Laboratory.

K. C. MAZUMDER, Jamshedpur.

The technique of spectro-chemical analysis is being developed at Tata. A non-recording micro-photometer is used for measuring the intensity of the spectral lines. The percentage determination is done by the method of internal standard. The agreement with the chemical determinations is good. When the method is adopted for the routine test a considerable saving of time will be effected.

12. Ferro-alloy industry in India.

K. N. P. RAO, Jamshedpur.

Indian steel industries have been depending on foreign supplies of important ferro-alloys, such as ferro-chrome, ferro-silicon, etc., but due to the situation brought about by the war, a modest beginning has been made. The ferro-alloy industry is a vital accessory industry and needs

to be put on a permanent basis. India is self-sufficient so far as ferro-manganese is concerned, but the quality produced is not quite suitable for the production of 'quality steels'.

The electric furnace used in the production of the important ferro-alloys and the production methods as well as the present state of production regarding ferro-tungsten and ferro-vanadium are described in the paper. The raw materials available in the country, the internal demand and the future possibilities have also been discussed.

13. Recent important developments in the metallurgy of iron and steel.

J. S. VATCHAGHANDY, Jamshedpur.

The paper plans to cover briefly some of the important developments in the field of iron and steel industry. The survey starts with blast furnace and leads up to the manufacture of cast iron, the different processes of steel-making, rolling mills, heat treatment, and inspection and testing of iron and steel. The influence of steady fundamental and industrial research as well as the impact of the contingencies of the war on the different phases of the industry have been shown.

The rule of thumb methods are giving way to essential knowledge of thermal, chemical and physical phases of the iron and steel making operations which has been put into the hands of the operator. In the field of heat treatment, the fundamental researches on the nature of the transformation of austenite have clarified the mechanism of the hardening of steel a knowledge which is being backed up by improved designs in furnaces, controlled atmospheres and modes of operations. Progress in methods of inspection and testing has been made along with advancements in iron and steel manufacture as well as with the developments in the field of physics and chemistry, such as spectroscopy, radiology, electron diffraction methods, ultrasonics, electron microscopes, etc.

14. The foundry cupola: high duty and special cast irons.

V. S. GANESH RAO, Jamshedpur.

The paper deals on cupola design and construction with special reference for the manufacture of different types of high grade cast irons. The general description of the manufacture of high duty irons is given for straight cast irons, inoculated irons, and alloy cast irons. It mentions the special cast irons for wear, heat and corrosion resistance, the alloying elements being copper, aluminium, nickel and chromium. The general principles for the manufacture of chilled castings, white-heart, malleable and non-magnetic castings in the foundry cupola is also mentioned.

15. Some experiments in lift irrigation in Travancore.

V. V. GOPALAKRISHNA AYYAR, Trivandrum.

Lift irrigation has been practised in Travancore from the past, but only manual lifting with Picottahs from wells or other water sources is commonly employed. The physical features of the country afford facilities for power lift irrigation for intensive paddy cultivation on a large scale. The rainfall is heavy. So it is necessary only to supplement this natural supply of water by pumping during the dry season.

With the inauguration of the Pallivasal hydro-electric project electrical energy has been made available within the State itself. So it was decided to conduct some experiments in paddy cultivation using electric lift irrigation methods and investigate the possibility of introducing the scheme on a large scale.

Experimental cultivations were taken up during the years 1941-42 and 1942-43, over 83 acres in the 1st year and over 989 acres during the

second year. They covered both the cultivation seasons, the Mundakan crop from October to January and the Punja crop from February to May. Complete data were collected regarding duty of water, rainfall, cultivation charges, usage of current for pumping, yield of paddy, etc. The results have shown that it will be profitable for the ryots to employ electric lift irrigation methods for intensive cultivation and that the scheme may be able to pay its way ultimately and that it will be advantageous to adopt lift irrigation methods in other places also where natural facilities exist.

Proceedings of the Thirty-first Indian Science Congress

Delhi, 1944.

PART IV—LATE ABSTRACTS, DISCUSSIONS, POPULAR LECTURES, LIST OF MEMBERS AND INDEX

CONTENTS

Proceedings of the Thirty-First Indian Science Congress

DELHI 1944

PART IV.

1. LATE ABSTRACTS

Section II, Physics.

36. On the activation energy of chlorine ions in alkali chloride crystal.

H. N. BOSE, Calcutta.

In polar crystals (W_I) the work necessary to remove a negative ion from the interior of the crystals to a point outside the crystal is different from W_L the lattice energy by an amount $\frac{1}{2}$ $e\varphi$. This paper deals with a method of determining this W_L from measurements made on the K-β spectra of the atoms concerned. The values obtained in this way for Cl ions in NaCl and KCl crystals are compared with the theoretically obtained values of Mott and Littleton in their second case, *i.e.*, when all the ions are allowed to move to their new positions of equilibrium. The difficulties and limitations of the method are also discussed. The result seems to lead to a very important conclusion.

Section III, Chemistry.

142. Light absorption of nickel acetate and nickel perchlorate.

K. VEERAIAH *and* M. QURESHI, Hyderabad (Deccan).

Light absorption of nickel acetate and nickel perchlorate in aqueous solutions has been studied spectrophotometrically in the visible region between 430 mμ and 760 mμ at different concentrations. In the case of nickel acetate, the molecular extinction co-efficient curve shows continuous absorption in the violet region and a maximum absorption in the red at about 715 mμ. Dilution of the solution results in an increase in the molecular extinction co-efficient at all wave-lengths, but this increase is more marked in the region of maximum absorption at the red end than in the region of continuous absorption at the violet end. The effect of dilution has been explained. In the case of nickel perchlorate, the general form of the absorption curve remains the same as with nickel acetate, but there is a distinct shifting of the band maximum towards shorter wave-lengths on dilution. The comparison of the curves of the two salts brings out the influence exerted by the anions on light absorption.

143. Photochemical formation of hydrogen peroxide from water. Part I.—With zinc oxide as a photosensitiser.

C. NARASIMHA CHARI *and* M. QURESHI, Hyderabad (Deccan).

The photochemical formation of hydrogen peroxide from water with zinc oxide as a sensitiser has been studied in detail both in sun-light as well as artificial ultraviolet and visible light. The yield of hydrogen peroxide increases in the presence of some organic compounds which presumably act as stabilisers. Of the nine organic substances employed for this purpose, phenol was found to be the best. An increase in the amount of zinc oxide produces a corresponding increase in the reaction rate which, however, tends to a limit with a constant intensity of light. From the increase in hydrogen peroxide with time, it has been concluded that the order of the reaction lies between 0 and 1. An increase in the pH has been found to increase the yield of hydrogen peroxide. It has been found that the photosensitive range of zinc oxide extends up to the violet, although from a

study of the absorption spectra of zinc oxide Goodeve came to the conclusion that the photoactive range lies in the near ultraviolet (>330 mμ).

The photosensitising activity of zinc oxide, prepared by different methods, has been studied and it has been found that zinc oxide, prepared from carbonate by ignition, has the greatest activity.

144. Autoxidation of vegetable oils.—Part I. Niger seed oil.

T. V. SUBHA RAO *and* G. GOPALA RAO, Waltair.

Niger seed oil is a semi-drying oil used as an edible oil and to a limited extent in the preparation of paints. The deterioration of niger seed oil on storage in the dark and the influence of sunlight on the rate of deterioration was studied by determination of the peroxide value, iodine value, refraction index, acid value and diene number. It was observed that niger seed oil undergoes autoxidation in the dark, and it was accelerated by sunlight. The increase in peroxidative rancidity was accompanied by a simultaneous decrease in the original orange-yellow colour of the oil. The reaction progressed in the dark even after removing the source of illumination showing photochemical after effect. There is an increase in the viscosity of the oil, with a simultaneous fall in iodine value and a slight rise in diene number, pointing to the formation of conjugated double bond polymers. A slight increase in acidity value was also observed. The natural colouring matter acts as an antioxidant and is preferentially reacted when the oil is exposed to light. Further work on the oxidative rancidity of other vegetable oils and the influence of external agencies such as light is in progress.

145. Synthesis of 1 : 2-di-*p*-Methoxyphenyl-*cyclo*hexanone.

SUNIL KUMAR RAY *and* D. K. BANERJEE, Calcutta.

In the expectation that 1 :2-di-*p*-hydroxyphenyl-Δ_1-*cyclo*hexene and the corresponding reduced dihydro derivative may prove to be valuable synthetic oestrogenically active compounds, the dimethylethers of the above two substances have been prepared.

Potassio-derivative of ethyl *p*-methoxyphenylcyanacetate was condensed with ethyl δ -iodovalerate when diethyl α -cyano-α-*p*-methoxyphenylpimelate, b.p. 215—220°/6mm., was obtained in good yield. The crude dibasic acid, obtained by the hydrolysis of the above pimelic ester derivative by prolonged refluxing with concentrated hydrochloric acid, was esterified by the alcohol-sulphuric acid method. Diethyl α -*p*-methoxyphenylpimelate b.p. 206—208°/6mm., thus obtained, was cyclised by means of sodium dust in dry benzene, but as the resulting β-ketonic ester could not be distilled without decomposition the crude product was hydrolysed by refluxing with 20% sulphuric acid. 2-*p*-Methoxyphenyl*cyclo*hexanone, which passed over as an oil on distillation in vacuum, solidified on standing and melted at 96°. Grignard complex, prepared from *p*-bromoanisole and magnesium was reacted with the above ketone and the crude carbinol thus obtained, was dehydrated by heating with fused potassium hydrogen sulphate at 180° to yield 1 :2-di-*p*-methoxyphenyl-Δ^1-*cyclo*hexene b.p. 210—212°/5·5mm. On hydrogenation of the above unsaturated compound over Adam's catalyst 1 :2-di-*p*-methoxyphenyl-*cyclo*hexane, b.p. 197—200°/4mm., was obtained in quantitative yield.

146. A new technique for the chemical estimation of thiamin.

BASIR AHMAD *and* GARGI BHARIHOKE, Lahore.

The essential difference between the original method of Jansen and the new method is the use of ethyl alcohol in the presence of K_2CO_3. Thiochrome can be extracted satisfactorily without using *iso*-butyl alcohol. Results obtained by using ethyl alcohol as a solvent for thiochrome were within the experimental error. The recovery tests were also satisfactory.

147. An improved technique for the estimation of nicotinic acid.

BASHIR AHMAD *and* AMAR NATH SHARMA, Lahore.

Different methods of the colorimetric estimation of nicotinic acid were carefully examined using yeast and urine as experimental materials. Over 20 new amines were studied and it is found that aniline with hydrochloric acid gives the best results. Between *p*H 4 and 5, the maximum intensity of the colour is developed and it is stable for three hours. The time of development of colour which is bright yellow is only 15 minutes.

148. Syntheses of acridine derivatives related to atebrin and acriquine.

RAM SINGH *and* GURBAKHSH SINGH, Lahore.

Atebrin and acriquine, so very well known anti-malarials, are the amino-alkyl derivatives of 9-amino-6-chloro-2-methoxy acridine. So far no investigation of the aryl derivatives of the same acridine has been undertaken. Therefore a number of compounds of the latter group have been prepared by the interaction, in the presence of phenol, of 6:9-dichloro-2-methoxy-acridine with the following amino-compounds.—*o*-, *m*- and *p*-toluidines, chloro- and nitranilines, anisidines, phenetidines, dimethyl and diethyl amino-anilines and phenyl hydrazine, *p*-amino acetanilide, 2:4- and 2:5-dichlor-anilines, *o*-iodoaniline, *o*-bromoaniline and *β*-naphthylaniline. Besides, such compounds as piperidine, *cyclo*hexylamine, urethane, glycine, and alanine have been successfully condensed with the acridine.

Attempts are being made to get their antibacterial nature tested.

149. Synthesis of substituted diamino-acridines.

INDER SEN GUPTA *and* M. L. AGGARWAL, Lahore.

Rivanol and Proflavin (both diamino-acridine compounds) and 5-amino-2 chloro-acridine monohydrochlorides are good antiseptics. The fact that the latter, with chlorine in the acridine nucleus, have very high bacteriostatic capacity led us to synthesise new substituted diamino-acridines with chlorine in position 4. For this purpose *m*-chloro-aniline was condensed with 2-chloro-5-nitrobenzoic acid. The condensation product on ring closure with phosphorus oxychloride gave 4·5-dichloro-7 nitro-acridine. This was further successfully condensed with the following amines:—1. Aniline. 2. *p*- anisidine. 3. *p*-chloro-aniline. 4. *m*- chloro-aniline. 5. 2:5-dichloro-aniline. 6. *o*- bromo aniline. 7. *p*- Bromo-aniline and 8. *o*- iodo-aniline.

The nitro-compounds formed above, were reduced to the corresponding diamines. For their antiseptic properties, the drugs are yet to be tested.

150. Characteristics of ricinus lipase and its effect on the rate of hydrolysis of different edible fats.

BASHIR AHMAD *and* R. N. SARIM, Lahore.

Ricinus lipase, the lipolytic principle of the castor-bean, has been isolated and studied intensively. It is found that (*a*) the optimum H-ion concentration lies between *p*H 3.6-4.2 and not between *p*H 4.7-5.0, as reported in earlier literature. It has also been found that H-ion concentration is independent of the nature of the substrate. (*b*- Optimum temperature has been found to lie near about 25°C and has also been found to be independent of the nature of the substrate.

Certain improvements have been made in the technique of the determination of lipolytic activiy. The relative digestibility of 35 samples of different, natural and artificial ghees, vegetable oils and animal fats, have been studied. For vegetable oils, the following order of decreasing digestibility has been observed, coconut oil, kadoo oil, seasame oil, almond oil, and cotton seed oil. Among the animal fats the pig tallow has been found to be the most easily digestible.

Section IV, Geology and Geography.

19. Contributions to the Geology and Petrology of the G. R. Formation and Associated Rocks.

C. S. PICHAMUTHU, Bangalore.

The area described in this paper lies at the extreme north of the Mysore State, and forms the northern end of the Chitaldrug Schist Belt. This is an interesting area since there have been differences of opinion regarding the structure of the area as well as the mode of origin of some of the rock types, and also because the rocks are some of the least metamorphosed and bear a close resemblance to those in the type area of Dharwar.

In 1936, the author visited the area during the course of which current bedding was discovered in the sandstones. A preliminary account of the geology of this area was given before the Easter session of the Indian Academy of Sciences in 1940.

The paper gives a description of the rocks of the area which comprise chlorite

schists, clays and shales, sandstones, quartzites, ferruginous quartzites, limestones, traps, quartz porphyry, and dolerite.

The paper ends with a discussion of the structure of the area, and is illustrated by a sketch map and photographs of outcrops and handspecimens.

Section VI, Botany.

55. A new root parasite of the tomato plant.

MOSES EZEKUOL, Bombay.

Sopubia delphinifolia has been found to be a parasite on the Tomato plant.

56. Abnormality in *Musa paradisiaca L.* sub sp. *Sapientum.*

A. K. GHOSH, Calcutta.

An abnormal banana plant producing a large number of inflorescences from the same plant was collected from village Horkhali, Dt. Midnapore, Bengal.

The morphology of these inflorescences is discussed in this paper with illustrations, and the previous records of abnormality in banana are reviewed.

57. Observations on the vegetation of Tripura Hill Tracts along the borders of Bengal and Assam.

KALIPADA BISWAS, Calcutta.

A detailed study of the plant community was undertaken in the Tripura hill-tracts along the borders of Lushai Hill within the native states of His Highness the Maharaja of Tripura.

The general feature of the vegetation of the area is more or less a denuded and open association of various ecological types of a rain forest. These types represent *associes* of different storeys of vegetation due evidently to extreme jhooming and exploitation of forest trees in different areas by the hill tribes. The total number of plants collected in this area are 560 of which Phanerogams—539, Ferns—21 and Fungi—18.

58. Edible and Medicinal Plants of Burma and Assam.

KALIPADA BISWAS, Calcutta.

The Eastern Army is much interested in the edible and medicinal plants particularly the latter as a result of their experience of starving hundreds of evacuees from Burma in their terrible trip to India either from the Manipur side or through the Hukum Valley rightly called "the valley of death"

A systematic list of species together with short notes on the uses of the different edible parts of the various species of plants is given in the paper.

59. A podostemad from Kumaon (Central Himalayas).

A. C. JOSHI, Benares.

A podostemad has been collected for the first time from Central Himalayas, from the bed of the river Kosi near Chanauda, about 15 miles from Almora and at a height of 4,500 ft. It belongs to the genus *Zeylanidium* Tul. and appears to be a new species of this genus.

60. Abnormal male flowers with vestigial ovules in *Ephedra intermedia* and their significance.

P. N. MEHRA, Lahore.

Abnormal hermaphrodite flowers are reported for the first time in a species of Ephedra. These consist of the usual two perianth leaves, followed by stamen-stalks bearing bilocular sporangia at the apex. The total number of sporangia may be 5 or 6. In the centre is present an immature ovule. The general construction is like that of the male flowers of *Welwitschia*. The significance of these observations is discussed.

61. The cytosome in the pollengrains. of Ephedra. .

P. N. MEHRA, Lahore.

Two unusual types of bodies are found in the body cell cytoplasm of the pollen grains of Ephedra. This has been observed in six species. One kind of bodies are spherical and are provisionally termed spherules. These occur invariably and disappear in fixatives containing acetic acid. The others are spindle-shaped and are termed spindle bodies.

Section VII, Zoology and Entomology.

85. A new species of the rare genus *Pseudechinostomum* Odhner from *Nettion crecca crecca.*

R. K. MEHRA, New Delhi.

Pseudechinostomum indicus n. sp. is described in this paper obtained from a common Indian Teal. It differs from the known type species, besides variations in the size and shape of the different organs, in the following characters.—

(*i*) Presence of a few extremely minute spines on the collar-lappets.
(*ii*) Absence of spines in the acetabular and post-acetabular regions.
(*iii*) Complete absence of prepharyuse.

86. Hormones in insects (?)

P. J. DEORAS, New Delhi.

Of recent years much attention has been attracted by entomologists towards the problem of endocrine secretions in insects. It is not yet definitely known, whether there are incretary activities in insects, similar to those found in vertebrates. Kollar, Kopèc, Fräenkel, and to a large extent Wigglesworth have shown that there are certain glands in the insects which could be supposed to have an incretary activity. Of these glands Corpora allata is supposed to secrete certain substances which have a definite effect on moulting and metamorphosis. The author while working on the morphology of Trichoptera, has found a great correlation between the size of the Corpora allata and the sex glands. Similarly ligaturing the maggots of *Sarcophaga* sp. and *Musca* sp. gave the same results as seen by Fräenkel in *Calliphora erythrocephala.* The work is proceeding.

87. On the histological structure of the midgut of mosquitoes.

RAJINDAR PAL, New Delhi.

No attempt has been made so far to study the histological or physiological differences which may be present in the stomach of various species of mosquitoes and which may be the direct cause of the failure of the malaria parasite to complete its sporogonous cycle.

The histological structure of the midgut of four species, namely, *Anopheles culicifacies, A. stephensi, A. subpictus* and *Culex fatigans,* has been carefully studied, and no marked histological differences have been found among them. The detailed structure appears to be the same as described by Grassi (1901), Christophers (1901), and Nuttal and Shipley (1903 for *A. maculipennis,* Mg., except for the peritrophic membrane. This membrane which according to some workers is absent in adult mosquitoes has been found in all the species examined. It is concluded that the histological structure of the midgut does not seem to influence the development of malaria parasite in the different species. Certain other physio-chemical factors such as *p*H concentration, etc., may probably prove to have an important effect on the development of the malaria parasite. These are being studied.

Section VIII, Anthropology and Archaeology.

22. Stone Age finds from Kandivli, near Bombay.

A. S. KALAPESI, Bombay.

I had the opportunity to collect a few specimens from Kandivli. The site is just near the back of the Hill whereon now stands the Physical Culture Institute. The finds were extracted from gravel and clay deposits.

Of the seven finds that I possess three are important. One of these (No. 1) is an ovate handaxe. It is about 6" long and 3" broad and 1" high and made out of a fine-grained brownish quartzite. Its condition is fresh, though the edge appears more blunt. On one side it is flaked all over.

The other two (Nos. 2 and 3) are flakes. Both are slightly rolled and yellowish. The first (No. 2- is like a right-angled triangle. It has a clear under-surface. The upper-surface bears unmistakable signs of chipping. The flake might have been used as a scraper. The second flake (No. 3) is like a miniature handaxe in shape. Subtriangular in section, it is polysided, four of which are smooth and flat. This flake could have been used as a chisel.

My handaxe resembles slightly the ovate handaxes collected by Col. Todd from the same area and it also resembles in shape and technique the one found by the Gujerat Prehistoric Expedition in the Savarmati Valley.

Section X, Physiology.

23. Innervation of the uterus and the female generative tracts: A comparative anatomical consideration.

G. K. Ghosh, Patna.

The problem has been approached by a comparative anatomical survey of Man, Primates, Rodents and Carnivora. The method used, has been water infiltration dissection with the help of low binoculars and dissecting microscopes. The morphological features have been compared and corelated.

From a consideration of my observations the following conclusions emerge.

(1) In the Primates, the body and the lower part of the uterus receives only the sympathetic supply directly from the Hypogastric plexus, while the vagina is innervated by branches from a ganglia situated in the Pelvic or Inferior hypogastric plexus, which receive, both the sympathetic and parasympathetic fibres. This is also true in the case of the Rodents and the Carnivora.

(2) In man, the hypogastric plexus before it joins the pelvic plexus, sends 2 or 3 branches which pierce the broad ligament and supplies branches to the fundus, the body of the uterus and the fallopian tubes. Well marked ganglia (Frankenhausers) are situated in the cranial part of the pelvic plexus and sends branches to the cervix and the upper part of vagina.

(3) The caudal part of the vaginal tract receives branches from the pudendal nerve.

(4) It is suggested that the dual nature of the nerve supply in the uterus and the generative tract—sympathetic in the upper segment, and mixed sympathetic and parasympathetic in the lower segment is corelated with the difference in nature of the function of these two segments.

24. The effect of ions on the impedance, permeability and excitability of unstriated muscle.

Inderjit Singh *and* (Mrs.) Sunita Inderjit Singh, Allahabad.

The impedance of dog stomach and frog rectus abdominis was measured by means of a wheatstone bridge using alternating current (1000 cycles/sec.) and chlorided silver electrodes. Cations calcium (up to 0·1 M $CaCl_2$), potassium (up to 0·15 M. KCl), hydrogen ions (from *p*H 8 to *p*H 5), magnesium (0·8 M $MgCl_2$) increased the impedance of frog rectus, but in dog stomach only calcium and hydrogen ions had similar effect. The anions decreased the impedance of both muscles in the order $Cl < Br < NO_3 < I < SCN$, but in frog rectus an opposite effect was also produced. Barium and calcium also had dual effect on frog rectus. The increase in resistance was associated with contracture. These results are in agreement with diffusion experiments. The exciting power of ions varies as their penetrating power, and they diminish the excitability to electric current and increase that if they increase the permeability to chemical stimulation. This is in agreement with the permeability theory of Lillie as regards chemical stimulation and those of Nernst and Hill, as regards theories of electric stimulation.

25. State of nutrition of Punjabis in relation to Thiamin.

Bashir Ahmad *and* Gargi Bharihoke, Lahore.

Diet survey of 26 different families and 12 individuals of Punjab has been made with respect to their thiamine intake. The thiamine intake was calculated

on raw as well as cooked food basis. It was found that on raw basis the value was between 689·35 μg per day to 3726·7 μg and on cooked basis it was between 333·96 μg per day to 2454·05 μg per day.

Thiamin excretion in the urine of 26 individuals was estimated on different days and the value was found to vary from 346·7 μg—1212·12 μg per day.

26. Thiamin content of wheat and wheat products.

BASHIR AHMAD *and* GARGI BHARIHOKE, Lahore.

Eight different varieties of the wheat of the 1941-42 crop and 16 varieties of the 1942-43 crop were studied for their thiamin content and it was found that the 1942-43 crop was richer in thiamin content than the 1941-42 crop. The value varied from 4 μg/gm—5 μg/gm in the case of 1942-43 crop and 2·56 μg/gm—4·59 μg/gm for 1941-42 crop.

Besides this the three different varieties of flour milled in three different ways namely (*i*) from hand driven chakki, (*ii*) from roller mill and (*iii*) from power driven chakki, were also tested for their thiamin content and it was found that the flour made from hand-driven chakki was richer in thiamin content than the roller milled flour or the power driven chakki flour.

27. Calcium and Phosphorous studies in relation to nutrition of the population in the Kangra valley.

BASHIR AHMAD *and* BANARSI DAS NARANG, Lahore.

Abnormalities of calcium and phosphorous metabolism in the Kangra Valley are well known and this constitutes a serious health problem. Total calcium, phosphorous and phytin content of all important cereals has been determined, and the calcium, phosphorous ratio of the available minerals in their typical diets has been determined. This ratio is found to be below *0·2*. Hence the ill effects are obvious.

Experiments have also been conducted on rats to see the effect of the typical diet of the Kangra Valley, with regard to the growth and the retention of calcium. Both growth and calcium retention was poor in this diet. When the diet was supplemented with calcium lactate, almost double the rate of growth and improved calcium deposition in the bones could be recorded.

28. Vitamin C in pine needles.

N. K. IYENGAR, B. C. BOSE *and* B. MUKERJI, Kasauli/Calcutta.

The search for cheap natural sources of vitamin C resulted in the discovery that Rose hips has a very high vitamin content of the order of 100—400 mgs. per 100 grams. Scientists in the Soviet Union have succeeded in preparing vitamin C concentrates from pine needles. Data regarding the vitamin C content of pine needles are not available.

A detailed investigation on the vitamin C content of pine needles available in abundance in Kasauli has been undertaken. Pine leaves fresh from the plant after removing the dried portions at both ends, were found to contain between 100 to 150 mgs. of reduced ascorbic acid (vitamin C) per 100 gms. The dried leaves collected from the ground was found to be poor in vitamin C, containing about 30 mgs. per 100 grams. The needles from young plants were found to contain about 150 mgs. on an average.

As it is now established that ascorbic acid is biologically active in the following forms: (1) Reduced ascorbic acid. (2) Reversibly oxidized ascorbic acid, and (3) Combined ascorbic acid. The pine needles were tested for the presence of all these forms of vitamin C. It was found that ascorbic acid is present in the reduced form only as the total ascorbic acid and reduced ascorbic acid were equal.

The edibikity of extracts of pine needles is not known and hence before recommending this for human consumption a study of the acute and chronic toxicity on animals has been carried out.

The stability of the vitamin C in the extracts, and the effect of the addition of cane sugar, to the extract have also been studied.

29. Prolactin and its bioassay.

B. C. Bose, N. K. Iyengar and B. Mukerji, Calcutta/Kasauli.

The international standard for the lactogenic hormone of the anterior pituitary body was established by the Permanent Commission on Biological Standardization in 1938. Since 1939, this standard is being distributed by the National Institute for Medical Research, Hampstead, London, under the name of Prolactin, Galactin or Mammotropin. This is available in the form of tablets of 10 mg. representing 10 Riddle units per milligram of the powder.

The assay of this hormone is carried by determining the degree of stimulation of crop-glands in different groups of pigeons or ring-doves by unknown samples and then comparing this with the corresponding effect produced by the international standard. The degree is measured by the increase in weight of glands. The accuracy of the method depends on the correct dissection of the glands which is not always very easy to demarcate in normal birds and for which detailed instructions are not available in the literature. The present work establishes a correct technique for this Laboratory with the help of morphological differences of normal and proliferated glands for enabling the assay of unknown samples in this Laboratory. A dose-response curve worked out with the international standard is also given for reference and guidance of future Indian workers on the subject.

The investigation carried out on 80 pigeons of mixed breed and sex and of 150 to 300 g. body-weight with 7 series of dosages of the international standard concentration of solution: 1 in 1000 (pH 8·4) given in 2 intramuscular injections per day for a period of 4 days produced a maximal effect of 325 per cent stimulation of glands in a dosage of 2 units/100 g. weight of the bird. For assaying samples at an optimum submaximal level of 200 to 225 per cent increase in weight of glands, a total dosage of 8 to 10 units per bird of 250 g. on an average was found to be a most suitable one. From the nature of the dose response curve and the standard deviation figures, it appears that unknown samples could be assayed with a fair degree of accuracy on groups of 8 to 10 pigeons with an allowable margin of ± 25 per cent.

30. Observations on the assay of insulin by the rabbit method.

N. K. Iyengar, B. C. Bose and B. Mukerji, Kasauli/Calcutta.

The rabbit method of Insulin assay first introduced by Marks is based on the observation of the fall in blood-sugar of rabbits after the injection of Insulin. As the percentage of blood-sugar reduction depends on the initial blood-sugar, the fasting blood-sugar of 40 rabbits of mixed breed, color and sex have been determined. The average value has been found to be 118 mgs./100 c.c.

In testing Insulin, the dosage employed by European workers is 0·5 unit per kilo, while the American workers use a dose of 1 unit per kilo. On account of this difference in the dosages, a dose-response curve for rabbits in India has been worked out. From a reference to this curve, it has been found that a dose of 0·5 unit per Kg. is suitable since this dose produces submaximal effect and is also in the region of proportionality between dose and effect.

The British workers bleed at hourly intervals for 5 hours and determine the blood-sugar in the pooled sample, whereas the American workers bleed at intervals of 1½, 3 and 5 hours after injection and estimate the blood-sugar in the pooled sample. The difference in response as measured by the two different intervals of bleeding has been investigated.

It is suggested that the American intervals of bleeding be adopted in assaying Insulin samples, since this involves a smaller number of bleedings. As the same procedure is adopted for rabbits injected with standard Insulin also the accuracy of estimation of the potency of unknown samples will not be affected.

31. Detection of pyrogens in fluids by biological methods.

B. C. Bose and M. L. Ahuja, Kasauli.

When solutions are prepared for parenteral injection it is essential to determine whether the method of preparation ensumes the absence of pyrogenic substances. For this purpose two biological tests are generally recommended—The hyperpyrexial and leucopenic reactions in rabbits following intravenous injection of the solutions to be tested. The present work is a critical study of both

the methods on a wide experimental basis with a view to find out the more suitable of the two for adoption in routine assay of samples in this laboratory.

From an investigation on the normal hourly and daily range of variation of rectal temperatures in rabbits it was found that by strict attention to certain details of technique the maximum and minimum temperatures recorded in a series of 100 rabbits were between 102·2°F. and 100·5°F. The average hourly variation for 100 rabbits was found to be 0·2°F. When stretched over groups of 5 rabbits this did not exceed 0·5°F. The day to day variation in any individual rabbit during the period of observation did not exceed 0·6°F. These variations are much less than what has been previously indicated by other workers.

After establishing these normals, a sample of strong pyrogenic water was submitted for bacteriological studies and 2 strains of pyrogenic organisms isolated from it—one aerobic, non-chromogenic; gram negative, non-motile, non-sugar fermenterbacillus belonging to the achromobacterium group; and the other aerobic, chromogenic, gram positive, motile, acid producing bacillus of the type of chromobacterium prodigiosum. Redistilled water cultures of each of these 2 strains of pyrogenic organisms suspended in normal saline at a strength of 25 million organisms per c.c. and autoclaved for 1 h. at 120°C. were tested for their comparative hyperpyrexial and leucopenic reactions on 11 rabbits. Injecction of the above suspensions in a dosage of 1 c.c./100 g. weight of animals produced a definite pyrexia of 1·5°F. and 1·9°F. respectively. There was a reduction of the leucocyte count in the same after injection of these fluids but the fall did not exceed 1783 and 2343 respectively per cu. mm. on an average, the normal daily variation in the same rabbits before injection being 1000 and 1600 respectively. In no case, a fall of over 400 per cu. mm. in W. B. C. count, which is considered Chapman as an index of pyrogenic response, was observed in our experiments.

It would thus appear that while the hyperpyrexia test was found to be a reliable and delicate method of pyrogen estimation the leucopenia test was unsuitable for this purpose in our experiences.

32. Investigation with blood phosphorous.

BASHIR AHMAD *and* K. B. SEHRA, Lahore.

Over 100 normal and pathological bloods have been studied for their content of different fractions of phosphorus, namely, (*a*) preformed inorganic phosphorus, (*b*) Adenosine triphosphate, (*c*) hexose diphosphate, (*d*) hexose monophosphate, (*e*) Glycerophosphate, (*f*) Acid soluble phosphorus, (*g*) Lipoid and nucleic acid phosphorus and (*h*) Total phosphorus. Norms for these have been established and observations have been made on the changes occurring under different pathological conditions.

33. Suprarenal cortex and carbohydrate metabolism.

A. M. J. SHIRAZI, Madras.

After establishing that a relationship does exist between suprarenal cortex and carbohydrate metabolism, an attempt was made to establish the link between the two.

The thyroid-adrenal mechanism which is supposed to increase glycogenolysis was eliminated by studying the effect of cortin on thyroidectomised animals, and ergotaminised animals. Then the exogenous source, which has been emphasised in recent years by Verzer and his co-workers, was eliminated by starving the animals for 110 hours, and till the blood sugar and liver glycogen rose to a very high level. Dambrois, Anderson had suggested lactic acid resynthesis as the source of sugar; but this theory was found to be not tenable as there was no chance for the lactic acid of blood to increase. The liver glycogen was found to rise after a fast of 110 hours when ketosis would be at its height. From this and other literature it has been concluded that probably cortex is related with gluconeogenesis. A suggestion has been made that cortex prepares the energy for the tissues, either in the form of phosphorylated glucose, or ketones; while insulin helps their utilisation (that is actual combustion). It is proposed that a study of ketone utilisation by the tissues should be done.

2. DISCUSSIONS.

I. MANUFACTURE OF PHOTOGRAPHIC MATERIALS IN INDIA.

(Sections of Chemistry and Physics).

1. PROF. M. Q. DOJA, Patna, opened the discussion.

DR. R. C. RAY, Patna, presided.

It is long since photography has ceased to be a luxury, it is now a necessity for civilized human life. Sciences, arts, industry, commerce, all need it. In the amelioration of human suffering it plays an important part, and so does it in the modern methods of instruction and recreation. A war too these days, cannot be successfully waged without its help. A nation therefore which does not produce its own photographic equipment is at a disadvantage. Short-sighted as this country has been in many other respects, this important industry did not attract the attention of eminent men in India, even after the first World War, when other countries began developing their photographic industries on a sound and independent basis. At present practically all the photographic materials used in India, are imported from foreign countries, the total value of which runs into crores of rupees. Apart from the financial loss involved, if at any time, due to war conditions or other causes, the supply is cut off or even curtailed, we shall find ourselves in great difficulties, as indeed we are finding these days.

The photographic industry is essentially a composite industry, depending for its success on a number of other subsidiary or "feeder" industries. Thus the manufacture of photographic plates requires the help of the glass manufacturer, the gelatin manufacturer, the manufacturer of chemicals and several others. In the same way, the successful manufacture of cameras can only be undertaken with the assistance of the metallurgical, optical, lacquer and other allied industries. Broadly speaking the industry comprises the manufacture of the following:—

(1) Photographic apparatus and appliances, such as cameras, filters, stands, lenses, etc.

(2) Photographic emulsions on different kinds of support like glass, paper, and cellulose derivatives.

(3) Photographic chemicals such as developers, toning agents, intensifiers, mountants, hardening agents, etc.

(4) Photographic sensitisers.

It is in item (4), the manufacture of photographic sensitisers, that I am particularly interested, and after a brief introduction, I shall review the work which has been done in this connection at the Patna Science College Laboratories.

One of the problems encountered in early days of photography was that the photographic plates were not sensitive to the spectrum in the same way as the eye is. Whereas the normal eye is sensitive to all the colours of the spectrum from violet through blue, green, yellow and orange to red, the early photographic plates were sensitive only to the ultra-violet, violet and blue. This is a serious defect particularly for the photography of coloured objects. It gives rise to incomplete" pictures, in which the light and shade effect is produced only by the violet and blue rays emanating from the subject. Vogel was the first to discover a remedy. He found that certain dye-stuffs, later known as "sensitisers", possessed the property of rendering photographic plates sensitive to light corresponding to the lower wave-lengths of the spectrum. As often happens with new discoveries, the accuracy of the observations of Vogel was doubted and his work was generally ridiculed. These experiments, however, were repeated by a Frenchman, Becquerel and later by an Englishman, Waterhouse, both of whom confirmed Vogel's observations. It is creditable that Vogel, notwithstanding the fact that his emulsions were slow, his dyes probably impure and his apparatus primitive, quickly grasped the fundamental relationship which underlies all work on sensitising, that these dyes sensitise in the same region as they absorb; for example a dye which absorbed green light would render a photographic plate sensitive to green. Once the existence of compounds of the sensiting type was established many substances were added to the list, and for the first time in the history of photography commercial sensitised plates called "Azaline plates" were placed on the market.

Up to the beginning of the present century, the dyestuffs which were known to possess sensitising characteristics, all belonged to different chemical groups, there were no essential chemical similarity between them. It was only after the work of two German chemists, Miethe and Traube, that a new group of sensitisers,

belonging to the *same* family of organic compounds was discovered. These were "the Cyanine Dyestuffs". Soon after the work of Miethe and Traube, at the Höcht Dye Works in Germany, were produced many sensitisers of the "cyanine" group, which were marketed under different trade names, such as "Pinacyanol", "Pinaverdol", "Orthochrome T", "Pinachrome", etc., and were protected by suitable patents. Since then a large number of compounds of this type have been synthesised, and now-a-days practically all the sensitizers used in the manufacture of photographic plates of different kinds belong to the 'cyanine" group of dyestuffs. It is remarkable that only small quantities of these compounds are quitet sufficient for purposes of sensitisation. They may be compared to vitamins in food, very small but very important.

The motion picture industry has benefited a good deal, from the scientific work on cyanine dyes. The introduction of filament lamps in place of inconvenient arc lamps for studio lighting was only possible because of the yellow sensitisers used in the manufacture of the films. The entirely silent nature of these lamps was an additional advantage when sound recording was added to the studio problems. The use of miniature cameras, particularly for photography indoors with artificial light, has been stimulated by the use of cyanine dyes. In order to get the fine details necessary, highly sensitive panchromatic materials of exceptionally fine grain are used.

In times of war the cyanine dyes are equally useful. Aerial photographs for reconnaissance purposes are usually taken on red sensitive plates, because it is the red rays which can successfully overcome the scattering power of the intervening atmosphere and produce well-defined images at long distances. These red and infra-red sensitisers are all members of the "cyanine" group of dyestuffs.

Prior to World War No. 1, the manufacture of these sensitisers was a monopoly of the German Chemical Industry. Outside Germany people knew very little about these compounds. As the war progressed the weakness of the position was realised, and the Allies began experiments and eventually succeeded in synthesising these compounds. Throughout the last war, all the sensitisers required by the Allies were prepared in the chemical laboratories of the University of Cambridge.

We in the Patna Science College Laboratories, during the last 2¼ years, under a scheme financed by the Board of Scientific and Industrial Research, have been engaged in the preparation of some of the more important of these sensitisers, from materials available in India. We have succeeded in preparing compounds similar to "Pinaverdol", the well-known yellow-green sensitiser used in the manufacture of "orthochromatic" plates, 'Pinacyanol" the red sensitiser used in the manufacture of "panchromatic" plates, and several others. In the synthesis of these compounds, the starting material in all cases, has been the coal tar distillation products benzene, toluene, and phenol, produced in Bihar. In quality these substances compare favourably with the imported products, and in some cases, for instance the orthochromatic sensitisers "Sensitin O" and "Sensitin D", are superior. The difficulties encountered in these preparations have all been solved, and it may be said that any enterprise in India for the manufacture of photographic plates will not suffer from a shortage of sensitising dyestuffs.

It is hoped that this 'discussion" will focus the attention of the Government, the scientists, and the industrialists of the country to this great national weakness—the absence of a photographic industry in India.

2. Dr. J. V. Karandikar, Cawnpore.

Various independent and interdependent industries produce the diverse and multifarious materials required in photography. These includes among others cameras, lenses, variety of apparatus and gadgets, plates, paper, films, chemicals and dyestuffs, etc. Cine-industry constitutes another colateral unit. The nature and extensiveness of the films like Agfa and Kodak are illustrative and informative on this point.

Immediate possibilities of manufacture of photographic materials here are governed and limited by (*i*) the quality of raw materials, (*ii*) the availability of equipment and machinery and (*iii*) trained labour. These naturally exclude the question of an immediate large-scale extensive production and hence a step-by-step attempt with a modest beginning seems to be only possible to start with. The manufacture of sensitive materials—only one of the host of items—may be considered.

A photographic emulsion is essentially a finely divided suspension of silver halides in gelatin, which is applied to a suitable support like glass, paper or celluloid film to make the materials sensitive. The stages involved in the manufacture are (*i*) mixing, (*ii*) digesting, (*iii*) setting and shredding, (*iv*) washing, (*v*) remelting and coating, (*vi*) drying, (*vii*) testing and final packing and disposal.

The chief raw materials required are (*a*) silver nitrate, (*b*) gelatin, (*c*) support, *i.e.*, glass plates, paper or film. A variety of equipment is necessary in carrying out the operations. Most of these operations have to be carried out in suitably illuminated dark-rooms. Paramount condition is the temperature and humidity control which requires a costly outfit and entails an initial capital outlay which forms the major portion of the investment.

The main difficulties encountered in the above work carried out at the Royal Institute of Science, Bombay were :

(*i*) non-availability of proper type of gelatin,

(*ii*) lack of proper equipment and machinery,

(*iii*) difficulties of practical nature due to absence of literature and data for working under tropical conditions.

Of these (*i*) was partially solved by purifying the available gelatin or by making necessary changes in the method to suit the particular type of gelatin.

(*ii*) by designing and constructing the equipment and machinery locally, and

(*iii*) by carrying out systematic experiments on a sufficiently large scale.

The work is still in progress, and the results obtained so far are very satisfactory and encouraging.

3. MR. S. BALAKRISHNAN, Bombay.

Photography made its début in the West about a century back. The beginning was small and the pioneers had great obstacles to overcome. Cameras with all refinements, which we now take for granted, were then unknown. A simple box with a pin-hole, in place of the modern lens, served for a camera. Shutters were not there. Negative material was slow and crude. It is said that several hours were needed instead of the split-second exposures now given and persons wishing to get their photographs made were made to sit several hours in the hot sun! Emulsion making was in its infancy. Colour sensitivity, resolving power, high-speed, keeping quality, etc., associated with the modern films and plates were then unknown. They used emulsions which had to be coated and exposed on the spot. Since then, the ceaseless efforts of numerous scientists and industrialists have contributed to the growth and progress of the Photographic Industry in Europe, America and, to some extent in Japan.

Our consumption of photographic materials is comparatively small. Yet this amounts to well over fifty lakhs; about Rs. 26,00,000 worth of photographic goods and about an equal sum under such heads as chemicals, equipments, electric machines, etc., are annually imported by us. Large as this figure is, it is bound to grow larger as years go by. India is a vast country and a huge market is awaiting development.

A large number of articles go under the head "Photographic materials". One will be surprised to find what a long list it makes. These articles may be broadly grouped, from the manufacturing point of view, under the heads :—

Sensitive materials,
Lenses,
Chemicals,
Equipment, and
Accessories.

The manufacture of sensitive materials is perhaps the most difficult one. Practically all the information on emulsion making are closely guarded secrets of the great factories. Those who aspire to enter the field anew will have almost to start afresh. If any one supposes that by following a few formulas given in books like the B. J. Almanac and others, he can turn out high class sensitive material as are commercially available he will be sadly mistaken. There are a few well-meaning enthusiasts, who hope to prepare in a hotch potch manner photographic papers and plates at a low cost and make huge profits. They will in due time find their money, time and energy wasted. Again there are others who imagine that they can themselves make all the machinery needed for making photographic sensitive material. One can only sympathise with them. The manufacturers of the machines have spent years in experiments and research in perfecting their machines. They incorporate several patented devices. These machines work with a fineness and precision impossible to attain in the first few attempts. It is because of such specialization at great cost that even the large manufacturers of sensitive materials buy their machines from them and do not manufacture themselves. No doubt certain experimental machines can be made. Given the necessary finance, work can be taken up on small scale coating machines, festooning apparatus, re-reeling machine, slitting machine, etc. Arrangements may be made for air-conditioning and certain qualities of paper coated with emulsions already worked out and tried : These may be marketed and experience gained.

For large scale commercial manufacturing, however, the machinery required will have to be imported from abroad along with a few experts. A careful selection of these by one who knows the line thoroughly is essential if costly failures are to be avoided. Local talents will have to be recruited and trained to take up the place of those experts in due course.

If we are to catch up with the standard of present day imported material, a well equipped laboratory with a number of scientists tackling the manifold problems, is essential. The importation of foreign experts alone will not solve the problem as they are unaccustomed to our climatic and other conditions. This is what a well known firm of manufacturers who had arranged to send some experts wrote in this connection: "We think it will be no easy matter to manufacture from the very beginning photographic papers in the same perfect quality as Agfa and Kodak, in the country the climatic conditions of which are still unknown to the specialists".

Supplies are now scanty. Very little material is now available in the market. However, after the war is over, imports will increase. But it may be that for some years to come, imports will not be able to cope with the demand. Even in normal days, the supply was not adequate to the country's demands. Thus the indigenous industry will have a good opportunity to develop. In the initial stages there may not be any serious competition. But when our output increases to the extent that the sales of the foreign companies get affected, then, it is likely, they will resort to serious competition. Competition may take the form of price-cutting, obstructing supplies of raw materials, spare parts for machinery, etc., tampering with the production and sales personnel, etc. It will, therefore, be the duty of the organisers of the indigenous industry to provide against such risks. Under the circumstances, a wise selection of machinery, proper arrangement for the continued supply of materials, right men in charge of research, production and sales, are matters which call for the urgent and careful attention of our experienced men who will be at the helm of affairs.

As I was connected for several years with a leading firm of manufacturers, I studied these problems from various points of view, corresponded with experts in the line in all parts of the world, collected important sales figures from confidential sources, sources of raw materials, machinery needed, men required, marketing facilities, etc. I am glad to be able to say that our country is eminently suited to manufacture all photographic materials and we can become self-sufficient in this respect in a very short time.

The cost of machinery, laboratory equipment, air-conditioning plants, erection, building, furniture and fixtures may be put down roughly as Rs. 7,00,000. Raw material, production cost, storage marketing and maintenance charges may call for another Rs. 8,00,000. It will, therefore, be safe to ensure a working capital of about Rs. 20,00,000. I need hardly stress the advantages of having one well-equipped manufacturing organisation rather than a number of small concerns, mostly ill-equipped for the manufacture of these highly technical and scientific material, the photographic sensitive material requiring precision machines, expert guidance and supervision. Pardon me for dilating on this point a little more. A number of stray individuals, fired no doubt, by enthusiastic ambition have made repeated attempts in the past and I may say here, several are still doing now; but unfortunately to no avail. Let us assess here for a while the national loss that this implies. Each such enthusiast wasting Rs. 10,000 or Rs. 15,000 in trying to manufacture, is depriving the country of the early possibility of establishing a central organisation like the one indicated above. If such well-meaning enthusiasts will come together, a national industry can come into being in no time.

There are already a number of chemical manufacturers in India and it should be possible for some of them to take up the manufacture of photographic chemicals.

Lens manufacture is as simple as it is difficult. The better class of lenses are the products of years of research and experience. These lenses are corrected for color, chromatism, aberration, distortion, etc. These call for optical glass of good quality, experience, precision grinders, etc. However, a start can be made with the simple box camera lenses. As the demand increases and experience gained, other types of lenses can be made. Patent rights may be obtained from foreign makers for manufacturing some of their lenses in this country. The progress in lens manufacturing will depend much on the demand that can be created which will again depend on the sales of indigenous cameras and other equipment using these lenses.

Equipments and accessories comprise a large number of articles. Among these, field cameras and certain accessories are comparatively easy to make. A number of efforts were made to produce them. For some reason or another, they have failed to make any headway. Either they did not have the proper machinery,

guidance or sales organisation. This shows that without a progressive outlook, great experience, enlightened management and the support of the trade, such ventures cannot succeed. I, therefore, invite the co-operation of all interested gathered here or outside, so that a powerful organisation can be set up for establishing on a firm footing the Photographic Industry in India.

4. MR. V. B. SHEWADE, Belgaum.

On the basis of my twenty years' experience of the trade I consider the starting of a photographic industry in India, a feasible proposition, provided it is run by experts on a well thought out system. A working capital of about 30 lacs of rupees will be necessary which it will not be difficult to find these days.

5. DR. P. K. KICHLU, Lahore. (*Communicated*).

Photographic Plates for Extreme Ultra-violet.

The sensitivity of photographic plates to extreme ultra-violet light is conditioned by the limitation that the gelatine of the emulsion with which the plates are coated, begins to absorb radiations below 2220 A° and become practically opaque as 1800 A° is reached. This opacity however is restricted to the region between 1800—1 A° approximately, the so-called vacuum region since all investigations must be carried out in a good vacuum due to the strong absorption of the air of the atmosphere even in very minute quantities. This difficulty is got over in two different ways :—

(1) The sensitive emulsion containing silver bromide is prepared with only a trace of gelatin. The gelatin present while sufficient to bind the bromide to the glass plate exerts no appreciable absorption of the light.

(2) Ordinary photographic plates are rubbed over by liquids which fluoresce under the influence of extreme ultra-violet rays and emit rays of sufficiently long wavelengths to produce a latent image.

These methods have been tried in the Physics Laboratory of the Government College, Lahore, in connection with the vacuum spectrographic work. The view based on the experience of the last 12 years seems to confirm that the plates prepared by the first of these processes provide the best solution of the problem. The plates are sensitive, fine-grained and free from fog or halation. In this method the silver bromide emulsion with only a slight trace of gelatin is prepared in the usual manner and allowed to mature at a previously determined temperature for a definite time. This is then frozen to a jelly and washed to dissolve away the soluble salts. Finally an emulsion is formed in hot water and poured over glass plates or films. After a regulated time the supernatant liquid is drawn off and the plates dried. They are ready for use immediately but are most sensitive after a further period of ripening depending upon the temperature. The silver bromide film though exceedingly thin and fragile sticks to glass tenaciously and any suitable developer may be employed for getting the photographs.

The sensitivity and usefulness of the plates depends to a very large extent upon the period of maturing and the quality of gelatin employed. The silver bromide grain increases in size with time and thus contributes an increasingly larger amount of silver bromide to the latent image. There is, however, another factor also which increases the sensitivity with time, *viz.*, the production of sensitizing specks of silver sulphide derived from the reaction with gelatine and collected on the surface of silver bromide grains. The quality of gelatine thus plays a particularly important role in the manufacture of these plates. Nelson's gelatine No. 1 has been successfully used, but Eastman Kodak Company's best photographic gelatine—we use No. 73-400—gives even better results.

A slight modification of this process consists in depositing the emulsion over a glass plate or film covered with gelatine. This may be obtained either by coating the gelatine directly or more conveniently by washing off the silver salt from a commercial plate by means of hypo leaving gelatine film behind. The sensitive film in this case is naturally more durable and stronger.

With regard to the second method which takes advantage of the fluorescent properties of oils and other liquids for producing the latent image, nujol and solution of sodium salycilate have been tried, but all these have only a limited value, the sensitivity being inferior as compared to the plate described above. Recently Messrs. Eastman Kodak Company have been employing a solution for bathing the plates. As this formula needs greater publicity than it appears to have received so far it is given here for the benefit of workers interested in the line.

Acetone (distilled)	..	... 500 c.c.
Ethyl Acetate (distilled)	..	... 500 c.c.
Dihydrocollidine	..	... 400 grams.

The plates should be bathed for two minutes in the solution and allowed to dry before use. The ultra-violet sensitizer must be washed off with acetone before developing.

II. INSECTICIDES.

(Sections of Agricultural Sciences and Chemistry.)

RAI BAHADUR D. V. BAL, Nagpur, presided.

The discussion was led by Dr. H. S. Pruthi. He stressed the investigation of indigenous materials for insecticidal value and urged the co-operation of the chemists in finding out the percentage of insecticidal principles.

Dr. Viswa Nath urged the necessity of having a standard insect on which various materials having insecticidal properties could be tried. The chemical analysis of a plant material was laborious and costly and wild goose chase of insecticides in the natural products was beyond the scope of chemists. Dr. Puri advocated the search for indigenous materials which contained the known insecticidal principles like pyrethrin, etc.

(Authoritative contributions from the participants were not received).

Dr. M. A. Rahman pointed out that a standard insect to test insecticides did not exist but the insecticides were tested on fishes in America and that method be adopted here. He enumerated the various necessary characteristics of an ideal insecticide.

Dr. M. H. H. Qadri advocated the use of mixed insecticides and said that each of the separate insecticides had feeble power but in mixture the insecticidal power was highly increased. Dr. Puri pointed out that insecticides in America were tested against flies and not against fishes. He stressed the preparation of synthetic insecticides and standardisation of vegetable insecticides.

Mr. A. Reid suggested that the spreading property of mixed oils as wetting and spreading agents required investigations for the control of insects. Irradiation by particular light rays and biological control of insects together with breeding of crops for insect resistance were few of the fruitful lines of investigation.

The president, Rao Bahadur Dr. D. V. Bal, in winding up the discussion, said that it was very encouraging to see that the problem of insecticides was discussed from different view points by the Chemists, Entomologists, Mycologists and others. The question of finding out and trying indigenous insecticides must receive immediate attention of the organic chemists in collaboration with the Entomologists and Plant Pathologists. In India considerable loss which is at present suffered by various field and garden crops could be easily checked if cheap and reliable indigenous insecticides were made available to the cultivators.

(Authoritative summaries of all speakers could not be obtained).

III. ELECTRO-CHEMICAL INDUSTRIES.

(Sections of Engineering and Metallurgy and Chemistry.)

SIR J. J. GHANDY, Jamshedpur, presided.

1. MR. G. C. MITTER, Bombay, opened the discussion.

An electro-chemical industry for the purpose of a survey may be classified under three headings: (*a*) the Technique, (*b*) Materials of Construction and (*c*) Power.

(*a*) *The Technique.*

A rough list of the more important electro-chemical industries has been drawn up in the form of a table (appended). There are three broad headings,

(1) Electrolytical,
(2) Electro-thermal, and
(3) Electric furnace products.

The technique of manufacture of some of the products by *electrolytical method* is simple enough to find a place in the post-war reconstruction scheme for the development of chemical industries in India. Industries manufacturing electro-thermal or electric furnace products have been left out from the review. They may be taken up by speakers following me.

A Light Alloy Industry.—In electrolytical method two distinct sub-divisions are made, (1) those using aqueous solution as the electrolyte and (2) those in which an electrolytic bath of fused salt of the metal to be extracted or its double salt is used. In non-aqueous or fused electrolyte besides the salt or the double salt of the metal, a fusible salt, such as an alkali fluoride or chloride is invariably added

to improve the electrical conductivity and fusibility of the bath. Base metals of lower order, such as Al, Mg, Be and alkali metals and also lead and sulphur are extracted by following this process. This method has thus a war-time significance because of the possibility of manufacture of metals, viz., Al, Mg, and beryllium which form important constituents of light alloys now brought prominently in use in the construction of air-planes, automobiles and trucks. From India's point of view, a light alloy industry may be considered as one of strategic importance not only for its war-time needs but because of its many peace-time applications in industrial and domestic uses. For, we must not forget that India is, as at present known, deficient in raw products for the manufacture of copper, zinc and tin. Aluminium and alloys of aluminium and magnesium, indigenuous ore reserves of which are happily enormous, must necessarily be made to replace copper and copper base alloys. To-day such replacements are being made not only as substitutes but in many cases as better alternatives for copper or copper-base alloys.

Aluminium and Magnesium.—Electrolytic manufacture of aluminium has recently been started under war impetus. It follows the orthodox line as far its technique is concerned. Its fabrication is already an established practice in this country and it has a ready market as well. There is also the bright prospect of its use as a deoxidising agent for steel (about 400 tons a year), in alumino-thermic reactions, in explosive (Ammonal), for acid containers and as electric power transmission cables. But the same cannot be said of magnesium. The electrolytic process of manufacture of magnesium as developed by the Dow Chemical Co., at its work at Midland (Michigan) and Freeport (Texas) in U. S. A. has no doubt been a remarkable success. But it is a complicated and expensive process involving the preparation of a suitable electrolyte of fused anhydrous magnesium chloride from sea water. The foundry and fabrication practice of magnesium are again a new technique and require expert supervision. To add to this difficulty is the uncertain financial prospect of the project, as it is known to-day that the magnesium development programme of U. S. A. aims at the gigantic production of 362,500 tons of the metal at the end of 1943 at a total cost of 339,000,000 dollars. But it can be assumed with a degree of confidence that the aviation and the aircraft industry which absorbs most of the metal at present is not going to be eclipsed, with the return of peace. It is also certain that the metal will be increasingly in requisition in various non-aircraft industries, most notable of which is the automobile industries and those manufacturing portable machines, equipments and tools, textile and stationery machinery; besides it has its use in pyro-technics and flash-light photography. With us to-day the important consideration is that the development of its use as an alloy with aluminium and titanium in place of copper-base alloys is essential in the national interest of this country for it is certain that in a crisis like the present one it will be unwise to depend upon imports of such metals as copper, zinc and tin, the present indigenous ore reserves of which are either insignificant or nil. There is no reason therefore not to investigate possibilities of manufacture of the metal by using a modified Dow process at places like Mithapur and Dharangdhara where magnesium chloride is obtained as a by-product, and at a price considered to be cheapest in the world. The metal can be obtained by other non-electrical methods the most notable of which is the Pidgeon's process developed by L. M. Pidgeon of the Canadian National Research Council where ferrosilicon is used to reduce magnesia obtained from mineral magnesite. But the electrolytic method is to be given preference because in that case magnesite may be left for other essential uses, viz., for refractories and special cements irrespective of the cost of production which in the latter case involves the production of the costly ferro-alloy.

In the category of products obtained from electrolysis of fused electrolytes the manufacture of beryllium and beryllium alloys from Indian beryl and the new method of manufacture of sulphur and lead from galena is of considerable importance, the former for its extraordinary properties which find new uses in accoustics and x-ray equipments and as fatigueless springs; the latter for the recovery of sulphur in which India is badly deficient.

Aqueous Electrolyte.—In the case of acqueous electrolyte, a long line of electro-chemical industries is already in existence, the most important of which are (1) the manufacture of caustic soda and chlorine and its derivatives classified in the category of electrolytic separation, (2) next comes the electrolytic oxidation and reduction products, subdivided as under :—

(*a*) Per-acids and per-salts,
(*b*) Hydrogen peroxide and Ozone,
(*c*) Organic products e.g., Iodoform, Bromoform, Sorbitol, etc.

The third most important industry under this head is the electro-winning of metals straight from its ore; fourthly is the allied industry of electro-refining and

lastly comes electro-deposition and forming. These industries are to-day well established abroad. In this country in some cases a start has been made only recently. The T. C. I., the Tata Chemicals and Mettur Chemicals are to-day manufacturing caustic liquor and chlorine on a scale large enough to meet a good part of the country's demands. The question of manufacture of hydrogen is being solved at Bangalore under the direction of Sir J. C. Ghosh and Dr. B. B. Dey in Madras is actively engaged in the electrolytic preparation of several organic compounds, such as benzidine etc., which are important intermediates in the plan of preparation of dyestuffs.

Electro-winning.—In Electro-winning technique the interest is now centred on the production of high purity manganese. High purity manganese* obtained by electrolysis is considered by analogy with the technical development of other high purity metals, such as copper, zinc and aluminium, to be a potential source of valuable alloys. Both in the United States of America and in Canada patents of interesting manganese alloys using high purity manganese of electrolytic origin have been taken which are reported to give amongst other properties such as high modulus of elasticity, the property of being hardened by cold work and by heat treatment, high coefficient of expansion, high electrical resistance with extremely low temperature coefficient and remarkable vibration damping capacity. The prospect of an industry involving the production and use of such a metal, ore reserves of which is practically inexhaustible, is worth investigation.

Electro-refining.—The technique governing electro-refining process has undergone interesting modification but none so interesting and at the same time so intriguing as in the case of reclaiming these metals from alloy scraps. In countries such as our deficient in metals of strategic importance, viz. copper, zinc, tin, reclamation from scraps takes an important place in the plan for the conservation of metals.

Electrolytic method of refining copper directly from scrap brass, bronze and nickel silver has been said to work successfully in Austria and U. S. A. In one of the methods referred to the case of brass, bronze and monel metals, electrolyte was cuprous chloride, cathode was a sheet of pure copper and the anode was the brass to be refined. During the electrolysis the electrolyte was circulated through reaction towers which were packed with the scrap material to be treated. This was necessary as the electrolyte was rapidly stripped of its copper content, in the refining cell, because more copper was deposited at the cathode than was dissolved at the anode.†

A method for refining bronze was developed by P. Weise in 1922.‡ He used a modified copper sulphate electrolyte in which the electrolyte was circulated over copper scales to refortify the electrolyte with copper, the tin content of the scrap being collected as SnO_2 in the slimes. This process is also known as the Lewin process and is protected by a U. S. A. patent.§ Details of these and similar methods are, I presume, deliberately kept secret. One has perforce to adopt his own technique when handling scraps in this country.

Electro-deposition.—Electro-plating is concerned with the production of metallic coating on metallic objects and to a limited extent on non-metallic objects with the primary idea of producing high quality finishes on the surface. Here also the principle is so simple that an electro-plater is tempted to take no consideration of certain important technical facts regarding (*i*) the setting up of a plating bath, (*ii*) conditions governing the quality and character of the deposit, such as current, temperature, concentration etc. The poor quality which is generally obtained in this country of electroplated articles is mainly due to complete disregard to the above factors.

But when it came to the question of preventing formation of scales or rust it assumed an importance of a different character. The protective plating on rust-forming materials, such as iron, calls for technique of a different character. Plating on iron or aluminium is difficult owing to the poor adhesive quality of the materials concerned due to their being not favourably placed in the electrochemical series. The technique of throwing an adhesive splash of brass, zinc or copper from cyanide bath followed by the normal process of plating with silver, nickel or chromium is to-day fairly wellknown.

Anodic Oxidation of Aluminium—The protection from corrosion by the electro-chemical method of throwing an oxide film on the surface of a metal or an alloy has its best application in the case of aluminium and its alloys known as the

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* 'Manganese and Its Alloys', U. S. Bureau of Mines Publication, 1939; *Metallurgist* (Supp. to *Engineer*), April 26, 1940, p. 108.

† M. Hosenfeld and G. Hansel, U. S. Pat., 1,757,047, May 6, 1930.

‡ *Z. Electrochemi*, **28**, 327-41, 1922 and German Pat., 312,941 (1917).

§ U. S. Pat., 1,574,043 (Feb. 23, 1920) and 1,890,856 (Dec. 13, 1932).

Anodic Oxidation Process. The resistance of aluminium to corrosion varies with the thickness of this oxide (or hydroxide) film. The anodic oxidation in a bath containing a chromate, bichromate or chromic acid gives a coating of protective film nearly 100 times thicker than the natural oxide film due to the atmosphere. The Guertler Process which consists in the immersion of the aluminium for 2 hours in a bath maintained at 90 to 95°C. of the following composition :

Pot. carbonate	...	...	25 grammes
Sod. bicarbonate	...	...	25 grammes
Pot. dichromate	...	...	10 grammes
Distilled water	...	...	1 litre

showed that some protection was afforded in the case of commercial aluminium, but little or no protection was obtained in the case of the various aluminium alloys, as it gives a much thinner film and, moreover owing to its nature, the immersion method fails to develop a resistant film in pores and cavities of the metal.

As the result of the anodic oxidation, the surface assumes a silvery white matt appearance and is thus admirably adopted to painting and varnishing and can also take a variety of tints or colours by simple immersion in a suitable dye solution. This is in accordance with the common practice of aluminium hydroxide being used as a mordant.

B. *Materials of Construction.*

Mention has often been made earlier of the difficulty of procuring the right type of electrodes, etc. It is not electrode alone that our attention is particularly invited to in electro-chemical enterprise. There are other equipments in electrochemical machinery which need as much consideration. The nature of these equipments depend broadly upon (1) those employed in electrolytic cells in which aqueous electrolytes are used, (2) those finding application in fused electrolytes, and (3) those in electro-thermic operations.

The principal items under (1) and (2) are

(c) Diaphragms, (f) Bus bars and power lines.
(b) Cathodes, (e) Circulating systems,
(a) Anodes, (d) Tank material,

In the case of (3) besides some items mentioned above the choice of furnace body and its linings and charging equipments are important considerations. The selection of suitable insoluble electrodes, especially anodes, not readily attacked by gases evolved or the corroding electrolyte, is limited to a few known imported articles, *e.g.*, chilex or fused magnesite of electro-winning for copper. Iron-silicon alloy is now obtainable in India and can form a tolerably good electrode in a electrolytic bath containing nitric acid. Lead and antimonial lead form the major part of electrodes used in a sulphuric acid bath. Graphite and platinum, however, owing to their insolubility have a general application in all electrolytic processes—their uses are being limited due to disintegration in the case of graphite and high cost in the case of platinum. Diaphragms which will resist corrosive bath, tolerably permeable to electrolyte with little electrical resistance, are as yet difficult to procure.

C. *Power.*

On the question of power it is not my intention to speak. The subject is a major one and deserves more careful consideration. It is, however, recognised that a proper survey of the existing power at the disposal of industries and an idea of the extent of its development should be made at an earlier date. On such a basis a chart requires to be made showing total power available for existing and future industries of this country. On the basis of this information power allotments to industries should be made in the order of their importance, the state of each being carefully regulated according to plan and requirements.

Conclusion.

I have endeavoured to indicate in the course of describing the technique of manufacture of some electro-chemical industrial products obtained by electrolysis the nature of the problems that are confronting us to-day. Briefly they are (1) the production of magnesium from magnesium chloride and a study of its fabrication and foundry practice, (2) the preparation of certain metals and alloys by electrolysis *viz.*, Be, Be-Cu, Al-Ti which have important uses in light alloy industries, (3) production of high-purity metals, specially manganese whose future prospects yet lie unravelled, (4) electrolytic reclamation of metals from scrap, especially with regard to metals of strategic importance, *viz.*, Cu, Zn, tin and lead as a necessary step in the plan for conservation of metals in which our country is deficient. More problems will be cropping up with the progress of electro-chemical ventures in this country and if they are to flourish and remain efficient, the need for a properly equipped research institution where such research could be undertaken to guide industries in the right direction is evident. I appeal to the authorities guiding the destiny of scientific researches in this country and planning at the

moment for the establishment of research institution to move for the creation of a Institute of Electro-chemical Research in India properly equipped and with adequate resources so that it shall tackle these and many similar problems which are bound to arise as we proceed to the goal of progressive industrialisation of India.

ELECTRO-CHEMICAL INDUSTRIES

- *Electrolytics*
  - *Fused Electrolytes*
    - Al
    - Mg
    - Na
    - Pb
    - Be
  - *Aqueous Electrolyte*
    - *Electrolytic separation*
      - Caustic soda & Chlorine, Oxygen, Hydrogen
    - *Electrolytic Oxdation & Reduction*
      - Per salts & per acids, Hypo-chlorites Chlorates,
      - H_2O_2 & Ozone
      - Organic products
    - *Electro-winning*
      - Cu, Zn, Mn, etc.
    - *Electro-refining*
      - Cu, Zn, Pb, Sn, Au, Ag, Ni, Bi, etc.
    - *Electro-deposition, plating and forming*
      - Commercial plating of Cu, Ni, Ag, Au, Cr, Cd, Sn, Zn, with special reference to recent improvements in bright plating and Electro-Galvanising and deposition of alloys
      - Special protective plating on Fe, Al, etc. Anodic oxidation of Al. Pickling and Polishing.
      - Electro-typing.
- *Electro-Thermics*
  - Gaseous products
    - Fixation of Nitrogen
  - Other products—Carbide, Cyanide, Synthetic Abrasives, Graphite, Phosphorus & Distillation products
- *Electric furnaces*
  - Ferro-alloys and steels
  - Non-ferrous products

2. Dr. H. K. Mitra, Jamshedpur.

Mr. G. C. Mitter in opening this afternoon's discussion advocated reserving Indian raw magnesite exclusively for the manufacture of refractory material and not using it for the extraction of metallic magnesium. He suggested the use of the Pidgeon process involving use of Dolomite for the latter purpose. In the absence of such figures before me, as the quantity of magnesium metal proposed to be manufactured and the cost of manufacture by this process, I do not propose to enter into discussion regarding this. I am however interested in the use of Indian magnesite as a refractory material and therefore would like to discuss the prospect of, or justification for, electric calcination of Indian magnesite.

Indian magnesite occurs in southern parts of the country. The metallurgical furnaces which are its largest consumer, in India, are located more than thousand miles away. It is to be calcined at high temperature to bring it down to a condition fit for use in such furnaces. In the process of calcination, from each ton of raw magnesite, theoretically, only about half a ton of finished magnesite is available. The balance of the half ton is lost as carbon dioxide gas—a valuable by-product.

Calcination at mines site has been advocated from time to time. It seems on the surface logical to do so; but what about the fuel? Either coal or electrically generated heat may be used. Hauling coal from Bengal and Bihar mines—this must be done as there is no suitable fuel near the magnesite deposits—offsets any saving in freight which is the advantage in sending calcined or 'dead-burnt', instead of raw magnesite from the mines.

The crux of the problem of calcination is cheap power. It should be really cheap. Even then the electric calcination will put the price of electrically calcined magnesite far above that of 'dead-burnt' magnesite now manufactured by using coal or gas as fuel. What, then, is the justification for such a step?

If electric calcination can yield a product superior in physical properties to that of the usual grade of 'dead-burnt' magnesite, the former can be used in places where the ordinary variety cannot be considered. Then alone there would be some justification for the use of the calcined product.

Indian magnesite contains very few fluxing material as distinct from the Austrian variety. It is, therefore, capable of yielding such a superior product, but, the end product aimed at should be fused magnesite.

Power required for this is of the order of 6,000 per ton. If unit electric power cost is of the order of 0·35 annas, the price of the finished product at consuming and would be about Rs. 100 more than the usual 'dead-burnt' product. If unit electric power cost is of the order of 2 pies the electrically fused material would still be higher priced by about Rs. 60 per ton.

The post-war world will probably see an All-Basic Furnace as a reality, that is to say, Basic Open Hearth Furnaces for steel making will be constructed of basic material and not partly with acidic material like silica brick as now. One such material would be electrically fused magnesia. But if bricks made of fused magnesia is to stand competition with other basic materials that would be available in India, or with similar imported material, then the price of power has to come down substantially below 0·35 annas and should be of the order of 2 to 2·5 pies per unit.

Electric calcination has another advantage in that the resultant CO_2 is obtained in a pure form. Subsequent conversion into 'dry ice' for use as a refrigerant, we believe, is rendered easier. Elaborate cleaning, prior to solidification, would probably be not required. Such recovery would justify shifting half of the raw material price to the accounts of carbon dioxide refrigerant. The cost of refractory material would proportionately go down.

3. Mr. Balaram Sen, Jamshedpur.

Of the electro-chemical industries that should be established in India, prime consideration should be given to the manufacture of electro-furnace and other products outlined below:—

(1) *Electro-furnace products.*

(a) Ferrous:—

Ferro-chrome
Ferro-silicon
Ferro-phosphorus

Ferro-tungsten
Ferro-titanium
Ferro-vanadium
Ferro-zirconium.

(b) Non-ferrous :—
Magnesium.

(2) *Electrolytic products.*

Manganese
Aluminium.

Of the above, immediate attention, in my opinion, should be given to the manufacture of ferro-chrome, ferro-silicon and ferro-phosphorus.

Ferro-chrome.—Suitable raw materials are available in Keonjhar and also in minor quantities in Singhbhum and Bezwada. The cost of chrome ore delivered f.o.r. may be in the neighbourhood of Rs. 60 per ton, the ore containing over 50% Cr_2O_3, silica less than 5% and FeO about 10%. The Mysore output of ferro-chrome is not expected to meet all-India demand in the future and there is therefore scope for manufacturing this ferro-alloy in northern India.

Ferro-silicon.—Ferro-silicon must be in large demand in the future not only for the steel trade but also for the extraction of magnesium from dolomite under the Pidgeon process. We should take note of the fact that the age is now coming for light metal alloys. Ample raw materials are available in the Singhbhum District as also in Bihar near Rajgir, and the stone can be obtained f.o.r. at about Rs. 10 to Rs. 15 per ton. The Singhbhum stone has approximately the following composition :

SiO_2	97%
Al_2O_3	1.3%
Fe_2O_3	·57%
CaO	Nil
MgO	·25%
Loss	·60%

Ferro-phosphorus is now in moderate demand but the possibility of an increased demand in the future cannot be lost sight of. The material is now being imported from abroad at a cost somewhere about Rs. 300 per ton. The raw material required for making ferro-phos is calcium phosphate which is available in fairly large quantities in Singhbhum District between Tatanagar and Ghatsilla. The ore is rather poor as the P_2O_5 ranges between 14 and 20%, but it has other useful components like iron (27%) and SiO_2 (11%) and to some extent should be self fluxing. The average ore is of the following composition :—

P_2O_5	17·56%
Fe	27·71%
SiO_2	11·83%
CaO	23·95%
Al_2O_3	5·93%
MgO	2·14%

The raw ore can be obtained at about Rs. 15 per ton f.o.r.

Of the other electro-furnace products ferro-tungsten can be made in small electric furnaces if ore concentrates continue to be made available from Rajputana. but the present reserves of such ore are unknown. The price per ton varies from Rs. 28 to Rs. 40 at site. Large quantities of titaniferous magnetite are available in Mayurbhanj and Singhbhum containing up to 20% TiO_2 (with 2·50% V_2O_5) but this ore cannot be used unless improved methods are introduced for beneficiating it. This ore is now being used for the extraction of vanadium but this is only a war time industry and may not stand competition with foreign supply in peace time.

Ferro-zirconium.—The raw ore may be obtained from Travancore. The quality is suitable as the material contains approximately 65% zirconia. The price of ore is approximately Rs. 120 per ton at site.

Magnesium.—Magnesium is now extracted under a new process from dolomite called the Pidgeon Process. The dolomite is first calcined and then mixed with crushed ferro-silicon into briquettes in the proportion of 3 of ferro-silicon to 1 of calcined dolomite and then electrically burnt to about 1500°C. The extraction of magnesium by this process is only a war time industry and reliable figures of cost etc. are not yet available, but claims have been made that the plant requires low investment, and the producing units can be built with great speed. Good grade of dolomite is available in large quantities in the Gangpur State. The ore can be delivered at about Rs. 3 per ton f.o.r.

Electrolytic Products.

Of the electrolytic products metallic *manganese* can be made from the low grade ores that are available in large quantities in Keonjhar, Bonai and Singhbhum. Such ores can be obtained at less than Rs. 10 per ton f.o.r. The method developed for the production of metallic manganese is by leaching and electrolysis, the electrolyte used being manganese sulphate. The process is claimed to be simple and cheap and adaptable to commercial utilisation. The power required for electric precipitation is reported to be not more than 4000 k.w.h. per ton of metal. The average low grade manganese ore of the above districts has the following composition :—

SiO_2	less than 5%
Al_2O_3	about 10%
Fe	about 20%
Mn	about 30%
P	less than 0·1%

Aluminium.—Very large deposits of bauxite are available in Lohardaga, Ranchi District, the ore containing over 60% alumina, less than 1% silica, Fe_2O_3 about 6% and titania less than 10%. The cost of ore f.o.r. may be in the neighbourhood of Rs. 15 per ton. Aluminium has no dearth of market and putting up a plant will depend on how much current can be made available, and on the availability of cryolite. For a small unit plant making approximately 5 tons a day, about 5000/6000 k.w. are required.

A modest beginning can be made by establishing an industry making annually 2,000 tons of ferro-chrome, 10,000 tons of ferro-silicon and about 1,000 tons of ferro-phos and 2,000 tons of aluminium. In all we might require an electric unit generating about 20,000 kilowatts. A factory can be established near Muri station, B. N. R. which is about 60 miles from Tatanagar. This site has the advantage of obtaining coal near at hand, and hydro-electric power, to be generated from the Hundru falls closeby.

Distances of the points of resources.

Muri station to Barkakana (coal)	36 miles.
,, ,, ,, Hundru (falls)	5 ,,
,, ,, ,, Nausashi (chrome)	274 ,,
,, ,, ,, Ghatsila (silica & phosphate rock) ...	82 ,,
,, ,, ,, Degana (Jodhpur, Tungsten concentrates) ...	957 ,,
,, ,, ,, Travancore (for Titanium & Zirconium ores)	1580 ,,
,, ,, ,, Dublabera (Titaniferous-Vanadiferous Iron ore)	90 ,,
,, ,, ,, Gangpur (Doloimte)	143 ,,
,, ,, ,, Barajamda (low-grade Manganese ore) ...	130 ,,
,, ,, ,, Lohardaga (Bauxite)	78 ,,

4. MR. G. V. APTE, Jamshedpur.

If an electro-chemical industry is to be established as a commercial success, cheap and abundant electric power is absolutely essential. The generation, transmission and distribution of electric power must be studied and dealt with on a nation-wide basis and not from a narrow angle of a private profit making concern or even the interests of a particular province. At present there are only two sources of generation of electric power on a large scale. First, in thermal stations depending upon coal and secondly, hydro-electric stations. As far as coal is concerned, it is practically concentrated in one small area and further, if we are to believe the geologists, the supply is not inexhaustible. Coal is urgently required for other national key-industries and therefore we must exploit the second source to the maximum possible extent. The hydro-electric stations are generally in remote parts quite removed from the place of any industry and therefore the cost of transmission is necessarily a very big item in any such scheme. In planning a nation-wide network we might very profitably take advantage of the experience of other countries especially that of Great Britian where during recent years a scheme of the highest national importance was carried through. Britain is known to be the seat of private enterprise and that nation is said to be very critical of the liberties of its citizens. However, in this particular instance, by the Electricity Act of 1826 electrical energy has been made the property not of any private concern but of the Government and therefore of the nation as a whole The private electrical concerns still remain but the entire electrical energy generated by them has to be sold to the Government Authority from whom they have to purchase back energy required for their own consumption or for their concerns or distribution to their consumers. The Electricity Commissioners further exercise control over every

generating station and net work has been laid so that energy generated at one point can be made available to any other point in the country. By this means always the most efficient sets are kept in operation and a drastic reduction in idle plant has become possible. The result has been a very considerable saving of the nation's fuel. A similar scheme will have to be worked out for us and a proper plan will have to be developed for inter-connecting the net works which are already growing in the different provinces of Bombay, Madras, United Provinces, Punjab etc. This necessarily means that it is State or the Government which will have to step in but there is nothing to be afraid of it as ultimately it is for the good of the nation as a whole. It is a well-known proposition that the higher the load factor on a system the more efficient is its working and a large network controlled by a single National Authority is the best means of obtaining the most efficient conditions of working. A second important aspect of electrical energy as applied to chemical industries is the nature of supply viz., A.C or D.C. At present, for generation and transmission on a large scale A.C is indispensable. Strenuous attempts are being made to develop high voltage D.C. transmission but we are yet far away from it. Those industries, therefore, which depend upon D.C. power will be somewhat at a disadvantage compared with those which can utilise A.C.

5. DR. J. N RAY, New Delhi.

The chief difficulty in the establishment of electro-chemical industries in India is the high cost of electric power as compared with the cost in the other countries. Moreover, the founding of a research institute would not immediately solve's India's difficulties, as we are a long way behind even in the matter of production of such simple equipment as diaphragms, electrodes, etc., etc. Instead of wasting public money on theoretical industrial problems, it would be better if some attempts are made to overcome the initial difficulties such as enumerated above

6. SIR S. S. BHATNAGAR, New Delhi.

After the last Great War, electro-chemical processes have assumed a great importance in the field of chemical and metallurgical industries and in fact, several purely chemical processes have been or are being rapidly replaced by the electro-chemical methods. For instance, the production of one of the most important alkali, caustic soda, is now largely carried out by the electro-chemical method, the chemical method of causticisation of sodium carbonate becoming rapidly out of date. Chlorine, another important product of this process, is one of the most important chemical both in times of war and peace. In the field of metallurgical industries, the production of magnesium metal, for example, which used to be accomplished through a chemical process, is now mainly carried out by the electro-chemical process. Recently, electricity has been found to be of great assistance in the production of organic chemicals, such as the polyhydric alcohols, and has incidentally saved considerable plant equipment and complicated machinery. The standard of quality of the electro-chemical products is generally said to be higher than that obtained in the chemical processes.

Apart from these advantages, the employment of electrical processes in preference to the chemical methods will affect considerable saving of fuel and although this may not bring about a proportionate reduction in the cost of production, this aspect will be a great boon to countries like India, with poor and rapidly depleting fuel resources. In view of these developments, I strongly feel that the future of chemical industries in India, having rather poor fuel resources but vast possibilities of cheap hydro-electric power, is intimately bound up with the development of electro-chemical processes. In fact, the B. S. I. R. has plans for providing a separate Electro-chemical Section in the proposed National Chemical Laboratory. Moreover, the Director of the Indian Institute of Science has told me that he wishes to locate an electro-chemical laboratory at Bangalore, where power and other facilities and the healthy conditions for industrial development may make this a happy choice, but I have no doubt that overlapping and duplication will be avoided excepting where absolutely necessary.

During the last few years of its existence, the B. S. I. R. has given attention to the study of some electro-chemical problems such as the manufacture of magnesium, beryllium, alloys, sodium hyposulphite, etc. These scattered problems need a house and I hope that as a result of your deliberations today, a place for developing an electro-chemical research centre in India will emerge. I can assure you that the Council of Scientific and Industrial Research, will, indeed, be very happy to have your suggestions and will, I hope, be willing to finance fruitful investigations on the development of electro-chemical processes in India.

7. DR. B. B. DEY, Madras.

The application of electric current to chemical industries has mainly been in the field of inorganic chemistry, such as in the electrolysis of brine for alkali and chlorine, for the preparation of hydrogen and oxygen and the chlorates, for the deposition of nickel, copper and chromium in the electro-plating industries, for electro-winning and electro-refining and in the electric furnace industries for the manufacture of ferro-alloys or of non-metallic products like calcium carbide and calcium cyanamide.

Although in bulk and value, organic products cannot compare with inorganic products cited above, they find such important applications as dye-intermediates, photographic developers and drugs that it is surprising that so little prominence has been given to the manufacture of organic products by electrolytic methods. This is not because electrolytic methods have not been employed in organic industries—in fact numerous applications have occurred—but to quote Thatcher, one of the pioneers of technical electro-chemistry in America, "it will probably be dificult if not impossible to cite another branch of applied science, in which such extreme reticence has been maintained".

The typical reactions of organic chemistry like reduction, oxidation and substitution may often be carried out with ease by electrolytic methods. Expensive reducing or oxidising agents like tin, lead peroxide or chromic oxide are dispensed with and there are no sludges of inorganic bye-products to remove. The course and final products of electrolysis are influenced by more than a dozen factors, the most important of which are: cathode material, composition of electrolyte, concentration of electrolyte and depolariser, current density, the presence or absence of catalysts and temperature. Once the right conditions for achieving a particular desired result have been determined, the electrolytic method has proved superior to the chemical method, because of the greater ease of control over the reaction.

Under the auspices of the Board of Scientific and Industrial Research, researches on the manufacture of dye intermediates like benzidine, tolidine, para-amino-phenol and others by the electrolytic method have been in progress for the past two years in the chemical laboratory of the Presidency College, Madras. The production of benzidine has been studied on a pilot-plant scale handling from twenty to thirty pounds of material in each operation. Both in this and in the case of para-amino-phenol, the results obtained by electrolytic methods have proved very satisfactory. Barring a few patent specifications, some of which proved to be misleading, there was little information in published literature on the details, such as the nature and shape of cathode material, the composition of the diaphragm, the concentration of electrolyte and depolariser, the temperature conditions, or the catalysts, a knowledge of all of which is essential for operating a commercial plant: The importance of research before launching on the technical production of organic compounds cannot, therefore, be over emphasised. India is on the threshold of great industrial developments. Organic chemicals will have to be produced in this country on a much larger scale than ever before, particularly for the dye and drug industries. Since we are favourably placed with regard to the supply of hydro-electric power, intensive research on the application of electro-chemical methods to the production of organic compounds should now be planned and carried out extensively in this country.

IV. STANDARDISATION OF CERTAIN TERMS IN INDIAN GEOLOGY.

(*Section of Geology.*)

DR. A. S. KALAPESI, Bombay, presided.

1. MR. N. N. CHATTERJEE, Calcutta, opened the discussion.

The subject is of great importance to the students and workers in Indian Geology. Any serious worker in Indian Stratigraphy must have consulted freely the official publication on the geological terminology published by the Geological Survey of India (*Memoir* Vol. 52 compiled by Sir Thomas Holland) and in so doing he must have come across certain stratigraphical terms derived from topographical names which have one or more alternatives. These alternatives may sometimes lead to unnecessary confusion and it is highly desirable that the authorities of the Geological Survey of India and of the other State Geological Surveys should be moved to standardise such terms and to adopt only one for such cases. A reference to Dr. M. S. Krishnan's book, 'Geology of India and Burma' recently published will show that he has suggested in some cases new alternatives, such as Kadapa, Damodar, Jubbulpore, Vempalle, Bundair, Varkale etc., thereby

causing further confusion in geological terminology. Recommendations regarding standardisation and adoption of only one particular term and to avoid alternative ones should be made to the authorities concerned. This move if carried out in the right direction will surely avoid all future confusion and will be of great help to the future workers in Indian Stratigraphy.

I think a few examples given below will make the subject quite clear to all.

1.	Cuddapah (Kadapah) system	According to Indian Geological Terminology (I.G.T.)
2.	Cheyair (Cheyyeru) series	,, ,, ,,
3.	Damuda series	,, ,, ,,
4.	Bezvada gneiss	,, ,, ,,
5.	Jabalpur group	,, ,, ,,
6.	Gulchera quartzite	,, ,, ,,
7.	Vaimpalli slates and limestone	,, ,, ,,
8.	Pulivendla quartzite	,, ,, ,,
9.	Blaini (Blini) beds	,, ,, ,,
10.	Barmer (Balmir) sandstone	,, ,, ,,
11.	Atgar (Athgar) or (Cuttuck) stage	,, ,, ,,
12.	Kamthi (Kamptee) series	,, ,, ,,
13.	Kundair (Khoond-air) stage	,, ,, ,,
14.	Kundghat (Khund-ghat) beds	,, ,, ,,
15.	Kaimur (Kymore) series	,, ,, ,,
16.	Makran (Mekran) group	,, ,, ,,
17.	Nahan (Nahum) stage	,, ,, ,,
18.	Papaghni (Paupugnee) series	,, ,, ,,
19.	Rajgir (Rajgriha) series	,, ,, ,,
20.	Tanawal (Tanol) series	,, ,, ,,
21.	Tirupati (Tripetty) sandstone	,, ,, ,,
22.	Tirhowan (Tirohan) limestone	,, ,, ,,
23.	Utatur (Ootatoor) stage	,, ,, ,,
24.	Paniam (Paneum) stage	,, ,, ,,
25.	Kirthar (Khirthar) series	,, ,, ,,
26.	Warkali.	

1. Cuddapah (Kadapah) system (according to I. G. T. *Mem.* 52).

W. King in *Record* G. S. I. Vol. II (1869) mentions Kuddapah formation. The rocks forming greater part of the Kuddapah and Kurnool Dt. in Madras Presidency. From the Kuddapah District the name Kuddapah formation has been assigned.

W. King in *Memoirs* G. S. I. Vol. VIII (1872) mentions Cuddapah town and district but coins Kadapah rocks and Kadapah series partly representative of the great Vindhyan series of India. King always mentions in this *Memoir* as Kadapahs.

Later on King in *Mem.* 18 (1881) writes Cuddapah formation on page 36.

Foote in *Mem.* 16 (1879) mentions Kadapa series in dealing with the geological structures of the East Coast.

From the above it appears that the name of this formation has been changed from time to time by the same author. It appears that there are 4 terms for this series namely—

(1) Kuddapah
(2) Kadapah
(3) Cuddapah.
(4) Kadapa.

I think this should not be allowed in the literature. It was perhaps assumed that as the name of the district is written in different ways the name of the formation should also be written in those ways. I think the sooner that practice is abolished the better for us. By way of argument I may say that the name of the district may be spelt in another fashion in future or the name of the district may be changed altogether but that should not lead us to change the name of the geological formation or to adopt alternative terms. We should always prefer only one term to denote a geological formation in the Indian Geological Terminology. But if the place name suffers frequent modifications or complete change in the hands of the political authorities or the Surveyor General who is responsible for preparing different editions of the Survey maps we can include suitable explanatory notes in the text of the terminology volume. As the terms are incorporated in the world's geological bibliography it is desirable that the priority of terms should be recognised and the use of only the older one should be encouraged and strictly enforced.

2. Cheyyeru (cheyair) series (I. G. T.).

King in *Mem.* 8 says :—The group is traversed by the Chey-air after which it is named more particularly as there is no large town in the field by which to distinguish it. But in Memoir Vol. 43, Sir Thomas Holland writes that the naming was done by W. King from the river Cheyyeru which traverses the series in the Cuddapah district.

From what has been just mentioned it is quite clear that there is sufficient confusion about this term even from one man's writings and it is better that one definite term may be adopted rather than alternative ones.

3. Damuda series (I. G. T.).

Krishnan's book—Damuda (Damodar) series.

Damuda is named by T. Oldham (J. A. S. B. Vol. 25, pp. 253 (1856) from the river which runs through the great Bengal coalfields in which the Damuda series is well developed and includes the chief coal seams.

Names proposed by Bland in Memoir Vol. I (1859) as Damoodah Group, Damoodah valley, Damoodah coalfields.

Mr. D. H. Williams published one geological report on the Damoodah valley about the same time. He also used these terms. But in Holland's terminology (Mem. Vol. 52) we find the term Damuda series.

Krishnan in his book has introduced Damodar series for the first time in 1943.

From what has been said above it is quite clear that three terms have cropped up for one geological formation leading the workers to unnecessary confusion. Once the name of a geological formation is coined it should remain in the literature without suffering any subseqnent change unless it is absolutely necessary to abolish it altogether due to sufficient geological reasons for doing so. It must be admitted on all hands that out of respect to the authority who had once coined and termed a geological formation the later workers should respect the priority of claim and accept those terms as final and should in no case be tempted to introduce or offer any other alternative ones.

4. Jabalpur Group (I. G.T.).

Named by T. Oldham who mentions in Records G. S. I. Vol. IV (1871) that in the vicinity of Jabalpur and stretching down the valley of the Narbada to the Sher river and a little beyond and forming also a narrow outcrop fringing the general line of the trappean boundary to the east and north of Jabalpur, a distinct group of rocks is recognised by Medlicott (J.G.) in 1856-57. First designed under the inappropriate name upper Damuda. Name Jabalpur group was substituted for upper Damuda.

Every body knows that at the present time the tower and district are spelt as Jubbulpore and it is a matter of satisfaction that the authorities of the Geological Survey of India have not changed this naming and added another alternative one within brackets. Krishnan, however, has introduced the term Jubbulpore group apparently after the present day spelling of the town. If we adopt this then it will necessarily follow that the naming of this geological formation will have also to suffer subsequent modification according to any future change that may take place in the naming of this town—a thing which should not be encouraged.

5. Gulcheru quartzite (I. G. T.).

Krishnan—*Gulcheru (Guvvala cheruvu)* stage.

Named by W. King (Mem. Vol. VIII, 1872) from the village of Gulcheru (Gulvala cheruvu) in the Cuddapah district.

King writes—"This series (Goolcheroo quartzite) is made up of a set of quartzites which form the fringing scraps and eastern slopes of the western hills from about Goolcheroo to Lorepoor on the Toongabhadra and a thick sub-group of slates and limestones of which the bottom of the long valley behind the scarp is made up.

From the above it is quite clear that this series may be named in different fashions, namely—

(1) Gulcheru
(2) Goolcheroo
(3) Guvvala cheruvu.
(4) Gulvala cheruvu.

I think it is evident that so many terms with such unsteady spellings should not be allowed to be incorporated in the bibliography for one and the same geological formation. It is rather our duty to standardise and adopt only one term for the advantage of the workers both in India and abroad.

6. *Vaimpalli slates and limestones* (I. G. T.).

Krishnan (1943)—Vempalle. Krishnan insists that Vempalle is the correct spelling of the village in modern maps.

Vaimpalli is named by W. King (*Mem.* Vol. VIII, 1872) from the village of Vaimpalli (Vempalle) in the Cuddapah district. The name of the place is also spelt by W. King as Vaimpully in Memoir Vol. VIII. From above it is quite clear that King knew the different spellings of the village Vaimpalli but he coined and adopted Vaimpalli and Vaimpully as the name of the geological formation. This is confusing but in the Indian Geological Terminology volume only Vaimpalli has been adopted. Krishnan's suggestion in 1943 will add further confusion. A reference to older editions of Survey of India maps will show many cases where different spellings were adopted in different editions. Moreover in the future editions of the topographic maps the names of places may again be slightly altered but that should not be the guiding principle for the geologists to change the name of the geological formation accordingly. It is high time that such terms which may create confusion were scrutinised and the older terms or some definite standardised terms were adopted once for all.

Several other examples may be cited.

In the foregoing pages I have made an attempt to place before the meeting the present position and have tried to show how the confusion exists with regard to certain stratigraphical terms in Indian geology and how the different authors have from time to time been tempted to add new names thereby causing further confusion.

I hope as a result of this symposium this matter will receive due consideration in the hands of the authorities concerned. If it is not possible to carefully scrutinise all the possible terms here at this meeting I would propose to form a small committee which should go deeply in the subject and come to some definite recommendations which may ultimately be forwarded to the Director Geological Survey of India, Mysore Geology Department, Hyderabad Geological Survey, Burmah Oil Co., etc. for consideration.

We may, however, if we all agree adopt the general principle that in order to avoid unnecessary confusion for certain terms in Indian Stratigraphy only one term should be finally adopted and should find place in the official Terminology volume and should be incorporated in the bibliography. The attention of the different authorities concerned may be drawn to this recommendation.

2. Dr. Kazi S. Ahmad, Aligarh.

I strongly support Mr. N. N. Chatterjee's proposal. I may say that I have experienced the same difficulty in the use of topographical terms in the books on Geography. The difficulty has been that books in English were written by translation from local Vernaculars and new books are being written by translations from current English books with the result that we have arrived at place names which do not exist in India. I suggest not only the standardization of the spellings of the various terms but also the standardization of pronunciation. I also plead for the simplification of the terms. Some of the terms of South India were so difficult to pronounce. A collaboration of the Geological Survey of India and the Topographical Survey of India may be necessary for the purpose.

3. Mr. N. L. Sharma, Delhi.

We are thankful to Mr. N. N. Chatterjee for giving examples of so many words in Indian Geological Terminology which require to be standardised. It is necessary for this purpose first to enquire from the various parts of India the correct pronunciation of the place name from which the particular name of a geological formation of India is derived. It is possible only then that the correct spellings can be given to these geological names. The names on the topographical maps even are often not spelt correctly. I think 'Damodar' is the correct name and Dr. Krishnan is, therefore, justified in changing 'Damuda' into 'Damodar' in his recent book on 'Geology of India and Burma'.

4. Dr. E. L. G. Clegg, Calcutta.

The Manual of the Geology of India was being revised and that the terms used in that Manual would be used by the Geological Survey of India in subsequent publications. In the past the spellings of place, names etc. were taken from the Imperial Gazetteer and geological synonyms had generally been given in the Bibliography (Holland, *Memoirs, G. S. I.*, Vol. XLIII).

5. MR. J. COATES, Digboi, Assam.

Dr. Clegg, in his remarks, has reminded us that the new edition of the "Manual" will become the official reference for the correct spelling of stratigraphical terms. He also indicated that the spellings adopted by the Geological Survey of India are customarily taken from the last edition of the Gazetteer. It seems to me that the last word will in practice rest with Geological Survey of India, but that Mr. Chatterjee's paper has been valuable in putting forward the suggestion that names once standardised should be kept unaltered—a suggestion that is obviously attractive—and that we here have now the opportunity to indicate to the G. S. I. what is the feeling on this subject of other geologists in the country.

6. DR. C. S. PICHAMUTHU, Bangalore.

Many of us are grateful to Mr. N. N. Chatterjee for bringing up this question of standardisation of nomenclature in Indian Geology before this session of the Congress. From his opening address, however, I notice that he is concerned more with the standardisation of the spelling of names. I would wish, however, that we went further than this and examined all aspects of this problem of nomenclature.

It is the experience of practically all of us that sometime or other we have come across the great diversity in the spelling of Indian place names. As one who comes from South India, I should like to give an illustration of this by referring to what is known in Indian Geology as the Warkalay Formation. H. J. Carter in 1857 refers to these rocks in his "Geological papers on Western India" as *Varkalay*. W. King (1882) was the earliest geologist to make somewhat detailed survey of these rocks, and he calls them the *Warkilli* beds, put in a footnote states "otherwise *Wur-Kullay*". It is interesting to note that in the geological map of Travancore accompanying King's report, the village is spelt *Wur-Kullay*, though in the legend it is given as Warkilli. Bruce Foote (1883) adopted King's spelling of Warkilli, but Medlicott and Blanford in their "Manual of the Geology of India" (1893) spelt the name of the village as *Warkalli*. The Travancore geologists have been spelling it as *Warkalay* and that is how it is referred to in all their published reports. On page 231 of Wadia's Geology of India" (1939) it is printed as *Warkali*. Dr. Krishnan in his "Geology of India and Burma" (1943) refers to these beds as Warkalli, but within brackets gives *Varkala* which is how the name of the station is spelt by the South Indian Railway. This gives us no less than *eight* variations in spelling the same name.

One can easily imagine the difficulties that must have beset the early geologists. They could only have obtained many of the names from local people, and what they heard they have attempted to transcribe into English. Since it is also not possible in many cases to represent the sounds of Indian names accurately in the English language, differences are bound to arise. There are also differences in the spelling of names in the various maps available to geologists, and so this again leads to variations.

It should, however, be possible hereafter at least to attain a certain amount of uniformity in the spelling of place names, but even if this is done, I think it would still be necessary in standard books on Indian geology, to give the different variations in the spelling of certain terms as footnotes.

If, as has been suggested, a committee of the Geology Section of the Indian Science Congress is appointed to go into this question, it seems to me that it would be better if it did not confine its attention only to the spelling of place names, but also bestowed attention on the standardisation of mineral and rock names. The Geological Survey of India is of course the premier scientific organisation to which we have to look to for a lead in this matter, but I am sure that it would welcome any help that such a Committee is able to render.

7. MR. D. K. CHAKRAVARTY, Lahore.

Two points have been raised. One of these, namely, the alternative spellings of place names involved in stratigraphical terminology as found in geological literature in India, can, in my opinion, be easily settled by following the principle of priority as followed in Botanical and Zoological terminology. The second point refers to new nomenclature involving a place name; for this we have to depend on the spelling shown on the latest edition of the topographical map of the area concerned published by the Survey of India. It is hoped that the first suggestion will receive due consideration at the time of compilation of the new edition of the Manual of Indian Geology that is going to be published by the Geological Survey of India, and the second one by the field geologists when they have an occasion for naming a new stratigraphical unit discovered by them.

8. Mr. W. B. Metre, Lahore.

Several of the geological formations in India are named after villages, towns, hills, and rivers, but these have been spelt differently in various editions of the Survey of India topographical maps. It will be convenient to seek co-operation of the Survey of India in standardizing the spellings of the place names.

Another matter which needs a more careful attention of this section is that where there are several names used to describe one geological formation, only one term should be retained. I agree that as far as possible the oldest name should be retained. But we should be prepared to discard old names which include beds of different ages. I have two such instances from Assam in my mind. In the earlier geological literature the term 'Cherra sandstone' appear to have been used to describe beds which are now known to include the lowest Tertiary beds and also a part of the Cretaceous rocks of the Cherrapunji area. Recently there has been a tendency in some quarters to restrict the use of the term 'Cherra Stage' to the lowest. Tertiaries of Cherrapunji, which according to the work of the officers of the Geological Survey of India correspond to Dr. Fox's Tura Sandstone Stage in the Garo Hills. As this correlation is based on very sound evidence there should be no difficulty in discarding the term 'Cherra Stage' and replacing it by 'Tura Sandstone Stage'. Another instance is that of 'Nongkulang beds', named after a village in the Khasi Hills from where Godwin-Austen made collection of fossils. Recent G. S. I. and B. O. C. work has shown that most of the rocks here belong to the Kopili Stage (Eocene), whereas Spengler who examined Godwin Austen's collection suggested Oligocene age for some of the fossils! In view of the doubts about the intended range of, and the actual age of, the Nongkulang beds, it is undesirable to continue using this term.

I suggest that the final choice of the most suitable terms and the standardization of the spellings of different names be left to the Geological Survey of India.

Resolution

At the close of the symposium the following resolution was adopted :

"Resolved that the Geology and Geography Section of the Indian Science Congress Association at its 31st Session held at Delhi in 1944 recommends to the Director, Geological Survey of India that in order to avoid unnecessary confusion for certain stratigraphical terms in Indian Geology derived from topographical names only one suitable term should be standardised and finally adopted and incorporated in the Geological literature".

"Resolved further that a copy of this resolution together with the full text of discussion on this subject be forwarded to the Director, Geological Survey of India for necessary action".

V. LOCUSTS AND THE SPECIES PROBLEM.

(Sections of Zoology and Entomology.)

Dr. Vishwa Nath, Lahore, presided.

1. Dr. K. B. Lal, Cawnpore, (*Communicated*).

Specific separation in insects has been based upon a wide variety of criteria, varying from the most flimsy to well-defined and stable characteristics. Next to structural peculiarities, differences of colour, size and hosts have been most commonly used to distinguish one species from another. The use of the latter characteristics alone in naming species has led to confusion in systematic work, indicating a definite need for agreeing upon the criteria for specific separation. For the locusts Uvarov's now well-established theory of phases has necessitated a revision of their specific nomenclature. In addition to phases, locusts are amenable to grouping into sub-species, varieties, geographical races and perhaps biological races. A clear understanding of the nature and, if possible, the limits of such groupings, appears to be of interest not only from scientific viewpoint but also from practical view.

In India the exact systematic status of the migratory locusts, *Locusta migratoria* Linn., is yet to be determined. Is it identical with one of the forms inhabiting the various regions of the old world or is it a form by itself? In entomological literature, the forms *migratorioides* R. and F., inhabiting Africa, is considered a swarming phase of the species *L. migratoria* Linn., written as a sub-species and referred to as a race. Should Uvarov's 'phase' have any taxonomic status at all

because the characters on which it relies are not only easily changeable but can even be produced at will, or should it be considered a combined equivalent of the two terms, 'sub-species' and 'biological races' because the characters, distinguishing phases, are both morphological and biological. Again should the same species embrace such divergences of form and habits as are typified by the different so-called races of *L. migratoria*, even though occurring in different lands? Or should specific division ignore differences other than that of morphology except for the reinforcement of its own purposes? It seems that in locusts intra-specific rather than inter-specific questions are the more important.

2. Y. RAMCHANDRA RAO, Bangalore, (*Communicated*).

The chief difference between a grasshopper and a locust would appear to be the ability of the latter to exhibit phase variations in response to changes in the environmental conditions. While the *solitary phase* form resembles an ordinary grasshopper, the *gregaria phase*, resultisg from crowded breeding, is in many species of locusts so markedly different that before Uvarov brought clear evidence to the contrary (Uvarov 1921), the phase form were considered to be entirely different species.

Studies carrried out during the last two decades have shown that, among locusts, under the stress of a concentration of population and a crowded breeding brought about by the developmtnt of favourable environmental conditions, a variety of changes—psychological, physiological and morphological—may occur. A crowd mentality is developed, and both in the adult and the hopper stages, greater activity and mobility are inxhibited. Whereas in the *solitary phase*, both the hoppers and the adults tend to possess a colour pattern stimulating the environmental coloration, in the *gregaria phase*, the pattern is of a vivid type designed to facilitate easy mutual recognition between members in swarms. Such changes may also be accompanied by morphological changes in the body of the locust in varying degrees, capable of being measured accurately by biometrical measurements.

A biometrical examination of a very large series of specimens of the Desert Locust has shown that, as a result of a crowded existence in the hopper stage, the adults become profoundly modified in regard to the relative development of the various parts of the body. In general, the wings tend to get more elongated, the femora to get shortened, the cheeks to get bulged, and the pro-thorax to get pinched in the middle. The differences are most pronounced in the extreme forms of phase variation, modifications being noticeable in all the different parts of the body, but in the intermediate forms the changes may be restricted to only one or two of them. The locust may be likened to a mass of plastic material that is capable of responding to the moulding action of the environmental forces to a greater or less extent proportionate to their strength.

It has also been observed that when the environmental factors causing the development of the gregarious phase become weak or are no longer operative, the *gregaria* characters gradually tend to disappear. In the hopper as well as in the adult stage, the glaring *gregaria* type of coloration tends to become transformed into the 'protective' type—similating the environment—characteristic of the *solitaria* phase. Even in the case of morphological characters, a reversion to the *solitaria* type is noticeable in the succeeding new generation. The phase characters would appear, therefore, to have no chance of becoming fixed, and thus to have no influence in the evolution of new species.

Whereas no local races have been found in the Desert Locust, although it has a wide distribution over Africa and Western Asia, five or more races of sub-species have been recognised in the case of the Migratory Locust—*Locusta migratoria* L. (Uvarov—1936). This is presumably to be explained by the fact that, although the Desert Locust has four or more distinct regions of habitat distributed in the desert zones of Africa, Arabia, Iran and India, no geographical isolation has apparently occurred, as swarm flights are known to pass freely from one desert breeding area to another at the change of the seasons. On the other hand, the sub-species of the Migratory Locust are confined to comparatively restricted geographical races. (1) The sub-species *Lucusta migratoria migratoria* is confined to the deltas of the rivers flowing into the Aral, Caspian and Black Seas, such as the Danube, the Don, the Volga and the Oxus; (2) *L. m. rossica* would appear to be confined to the forest areas of Central Russia (Waloff—1940); *L. m. migratorioides* to parts of tropical West Africa; (3) *L. m. capito* to the island of Madagascar; and (4) *L. m. manilensis* to south-eastern Tropical Asia and to the islands of the Philippines and the Malay Archipelago. The evolution of these distinct sub-species would appear to be due to their geographical isolation, there being but little possibility of the inter-mingling of the swarms of these sub-species with one another.

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3. M. L. ROONWAL, Benares Cantonment, (*Communicated*).

Researches initiated by Uvarov (1921) have shown that the locust and grasshopper species possess a high degree of plasticity. *Locusta migratoria* Linn., for instance, exists in two phases—gregaria and solitaria—which are morphologically so different from each other that formerly they were regarded as two quite different species. But now we not only know them to belong to the same species, but can transform one phase-form into the other at will in the Laboratory. It must be stated, however, that the phase variations are not inheritable and have therefore no genetical significance.

The Indian locust—*Schistocerca gregaria*—exhibits well-known morphological differences in its two phases, but the differences in their eye-stripes were first noticed by the author in 1936. Their details are as follows :—

Phase gregaria	*Phase solitaria*
1. Only 6 eye-stripes present. Interstripes impure white, very often extensively invaded by chocolate pigment of the stripes.	1. 6 or 7 eye-stripes may be present. Interstripes generally clear, white not invaded by chocolate pigment.
2. Always with 26 antennal segments.	6. 6-striped individuals always with 27 segments. 7-striped individuals with 28-29 segments.
3. Always undergo 5 moults, and thus have 5 hopper stages, the sixth stage being the adult.	3. Some of the individuals have an extra moult, *i.e.*, undergo 6 moults, so that there are 6 hopped stages, the 7th stage being the adult. The rest have 5 moults.

The hoppers when they first hatch out of the egg have no eye-stripes, the first stripe being laid a few days later. Subsequently a stripe is added with each moult, so that the 6-striped adult is produced after 5 moults. The 7-striped adults, however, are of two kinds. One half of them are produced after 6 moults, the rest, though completely formed after 5 moults, have two stripes laid after the second moult.

The 6-striped individuals are also of two kinds. Those in the gregaria phase have 26 antennal segments, but individuals with the same stripe-number in the solitaria phase have 27 segments.

In India the ratio of 6-striped to 7-striped individuals in *Sphistocerca gregaria* is as 72 :28, but in Africa their relation is almost reversed, the ratio being 34 :66.

The stripe-numbers are significant. Rao (1937) thinks that the stripe number goes with the locust phase. In the gregaria phase all the individuals have 6-striped eyes while in the solitaria they are mostly 7-striped. The stripes seem also to be linked with sex. The following is an analysis of the solitaria populations :—

6-striped	...	63%	37%
7-striped	...	35%	65%

It is possible that *Schistocera gregaria* has two different races—recognisable by differences in the number of eye-stripes—in India and South Africa. This view has so far not been put on a firm basis for lack of data regarding Western Asia and East Africa.

It may thus be concluded that seemingly insignificant changes in the environment can produce striking variations in morphological and physiological characters of the locust. But the question is, can one reasonably assume that these plastic species will one day split up into a number of more stable systematic units? The answer is two-fold. Some types of variations, like the geographical variation, have a distinct species-forming value. Others, however striking they may be (*e.g.*, the phase variations), have no species-forming value. Still others, like variations in the eye-stripe numbers may or may not have a species-forming value, but since they are sharp, discontinuous and inheritable, the author credits them with this value.

4. DR. M. A. H. QADRI, Aligarh.

The occurrence of polymorphic forms among the locust species has led to

confusion in their taxonomy. Polymorphism may be due to one of the following causes :—

1. Phase variations, 2. Size variations,
3. Colour variations, 4. Abberrant variations,
5. Blastogenetic variations.

Of these five types of variations only the last kind is inheritable, the first four are not.

1. *Phase variations* : The phase theory maintains that the locusts occur in forms which are different from one another as regards coloration, morphological characters, behaviour both in the immature stages as well as in the adults. Since these forms are interchangeable and periodic they are appropriately called phases. A given species may exist in three phases, viz., *phasis gregaria, phasis solitaria* and *phasis transiens.*

In the gregarious phase the hoppers are sharply coloured black and orange or black and yellow, though the colours don't remain so bold in the adults. The pattern of the compound eyes in the adults, and length-ratios of certain organs such as the fore-wing, hind-wing and the pronotum are different in the two phases. Both the hoppers and the adults display great activity and high nervous tone.

In the solitary phase the colour of the hoppers and adults is influenced to a great extent by the physical environment. The individuals remain calm and passive for the most part.

In the third phase or the *phasis transiens*, the solitary locusts are on the way to become gregarious locusts or *vice-versa.*

Recent experiments in India and abroad have shown that a change of colour and presumably of phase, can be brought about artificially as, for instance, by forcing activity on solitary individuals or changing the colour scheme of their background. In nature, however, such colour patterns may not result as an influence of individual's activity or its environment, but may be just due to inheritance, for the black pigment of the gregarious phase is seen to be bodily transmitted in the eggs and sperms that connect the successive generations. The oxygen uptake and the body temperature is visibly higher in the gregarious than in the solitary phase.

Since the phases have been shown to have no specific significance, a revision of locust taxonomy has become necessary.

2. *Size variations* : It is essential that these variations should be distinguished from the apparently akin biometrical variations of different phases which arise from changes in the habit of a locust species. An instance of the latter type are the size variations in the five sub-species of *Locusta migratoria.*

3. *Colour variations* : Colour variations mainly follow changes of phases and are thus not very important in taxonomic studies. The truly inheritable colours must be distinguished from the colours produced by a change of phase.

4. *Abberant variations* : Abberant forms are very common among the Acridiidae, and it is therefore very important for locust taxonomy that conclusions as regards the identity of a normal character be derived from studying a very large number of cases.

5. *Blastogenetic variations* : The morphological features of this type are the ones by which species can be reasonably separated. They are inheritable and permanent.

Several important species of locusts and grasshoppers need further studies for ascertaining their correct specific and sub-specific position. *Schistocerca, Cyrtacanthacris* and *Orthacanthacris* may be cited as examples of these.

VI. ZOOLOGY AND THE FOOD PROBLEM.

(Sections of Zoology and Entomology.)

DR. VISHWA NATH, Lahore, presided.

1. MR. S. K. SEN, Mukteswar, *(Communicated)*.

Animal husbandry is usually regarded as being more the concern of the practical farmer than of the zoologist. But when one is faced with problems that concern the primary urge of human life, the urge of food, one readily recognizes the need of including animal husbandry, veterinary sciences, genetics and zootechny in the science of zoology.

The value of India's animal industries has been estimated at Rs. 1,300 crores per annum, including Rs. 540 crores which represents the value of milk and milk products. India's resources in milk and milk products may be augmented by the improvement of the indigenous bovine stock by breeding and the provision of

more fodder and better grazing facilities. It is the concern of the systematic zoologist to describe and designate the indigenous breeds of milk cattle in accordance with the rules of zoological nomenclature, so that they may be improved by selection breeding. It is also desirable to castrate scrub bulls in rural areas. The fodder problem can be best solved by growing both fodder and cash crops on one's holdings. The outturn of the produce can be increased by the adoption of scientific methods of agriculture and the proper utilization of cow-dung manure. Equally important is the problem of cattle nutrition. This is greatly influenced by certain forms of helminth infestations, which provide almost unlimited scope for research for the zoologist.

The notion that buffalo is a better milker than the cow is not based on incontestable facts. Preliminary investigations have shown (Sen, 1939) that protection afforded to cattle from bites of flies results in a distinct increase in milk production. Both these questions await fuller investigation.

The *deshi* fowls are capable of being rapidly improved by selection and by the method of breeding known as 'progeny testing'.

Ichthyology and apiculture may be regarded as side lines of animal husbandry. The possibility of breeding marine fishes in inland waters and of domesticating *Apis dorsata,* the honey-bee yielding the bulk of honey in India, merits attention of workers in these lines.

In order to afford protection to livestock from disease it is essential to know the life-histories of the parasites and it is in the field of animal husbandry that the collaboration of the zoologist is most needed.

Improvement in the method of utilization of India's food resources may be effected by developing dairy husbandry in rural areas.

2. DR. SUNDERLAL HORA, Calcutta.

The fishery resources of India; the location of the principal fisheries; the effects of the existing emergency on the finishing industry; the measures that should be taken to conserve the present supplies, with particular reference to the fisheries of immature fish; establishment of nurseries for the restocking of tanks, reservoirs, rivers, etc; the need of conducting investigations on inland fisheries with a view to increasing the food supply in the country and to securing regional self-sufficiency; the necessity for studying the effect of factory effluents on the fisheries of the streams polluted by them and of dams and wiers on the movements of migratory fishes; an investigation of the most suitable species for use under diverse conditions in different localities in the campaign against malaria; the need for reorganising the taking and distribution of fish under the emergency conditions and the stoppage of wastage in any form by the proper preservation of the excess quantities netted in certain fishing areas and the full utilisation of all waste products.

In dealing with the subject as outlined above, zoological studies on the ecology, bionomics and life-histories of the principal food-fishes of India can lead to considerable improvements in the existing fisheries and scientific investgations conducted on a well-planned, all India basis can prove very effective for the development of the fishing industry, which is even now next to agriculture and animal husbandy in its economic importance.

3. DR. C. C. JOHN, Trivandrum, (*Communicated*).

Fisheries play a great part in providing food to the people, and although fishing is an important industry in many parts of the British Empire, in India, sea fishing is comparatively undeveloped. This is mainly due to the coastal nature of the fisheries, lack of suitable harbours and fishing crafts. But these are not exclusive factors. The improvement and expansion of marine fisheries is closely linked up with biological investigations regarding the migration, shoaling grounds, breeding seasons, feeding habits and food of fisheries. The study of the food and the feeding habits of fish is one of the best methods of locating important fishing grounds. Many instances of this are available in the literature on sea fisheries. In India, so far, work of this nature has stimulated very little interest. In this connection reference may be made to the papers published by Sewell (1913), Hornell (1923), Hora (1934) and Job (1940), and to the unpublished work of Sreedhara Menon of the Travancore University. The last worker has classified shoal fishes into three groups—microplankton feeders, macroplankton feeders and predacious fishes.

From a review of the work carried out in India, it appears that we have been concentrating on morphological and systematic study of marine organism irrespective of its value for the improvement of fisheries. In order to discover new

fishing grounds, facilities which are lacking at present, must be provided for extending the scope of work beyond the littoral zone.

In the case of freshwater fisheries the study of food and feeding habits of fish are important not only for conserving and developing existing fisheries but for the protection of valuable fisheries from the ravages of predacious varieties of fish found in our important river systems. The freshwater biologists have to see that young fishes are properly protected during their migration, that facilities are provided for stocking them in suitable reservoirs, that indiscriminate fishing is avoided and that predacious varieties, which are injurious to the fisheries, are eliminated.

Recent investigations conducted in the Marine Biological Laboratory at Trivandrum have shown that *Wallagonia attu* which is commonly believed to be a scavenger fish is in reality a predacious type of the first magnitude.

It is, therefore, clear that the study of the food and feeding habits of fishes is of fundamental importance in the development and expansion of fisheries.

4. Dr. Hamid Khan, Lahore.

To augment the fisheries of a country scientific knowledge of fishes is a necessity. Such a knowledge comprises—

(*i*) information about breeding habits, development and life history of fishes, including study of eggs, their hatching and rearing of fry.
(*ii*) Qualitative and quantitative study of food, animate and inanimate on which the fish feed.
(*iii*) A study of growth (to discover rapidly growing type).
(*iv*) Study of migration (this necessitates the study of fish ladders to facilitate the passage of fish up the stream to reach their spawning grounds).
(*v*) Study of histories of their enemies, friends and of their diseases and their control.
(*vi*) Study of environment suitable for the propagation of different species and effect on their growth.
(*vii*) Fish culture and propagation of choice kinds of fish in public and private waters.

Our knowledge regarding inland fisheries is very meagre. No attention has been paid to the fisheries in the canals. Rural pisciculture has only recently engaged the attention of pisciculturists.

The practical aim of Fisheries Research, therefore, is to develop the fisheries of the country to their utmost capacity. Zoological studies and research are thus urgently needed to conserve, augment and utilize in the best possible way the fisheries sources of our country.

5. Dr. Hem Singh Pruthi, New Delhi.

Of all groups of animals insects are most intimately related to human welfare. They constitute one of the most important rivals of man in exhausting the food resources of the country.

They injure the food-plants by boring into roots and stems, by nibbling leaves and flowers, and by eating fruits and seeds. Insects are also responsible for the transmission of virus diseases from one plant to another. Potato, sugarcane and tomato, all of which are important food-crops, are attacked by insect borne diseases. The estimated total annual loss caused by insects to plants in India is at least Rs. 800 millions, which is about 10 per cent of the total value of Indian crops.

In addition to damage to standing crops insects cause a great loss after the food-grains have been stored. Stored rice and wheat alone suffer an annual loss of Rs. 2 crores from the attacks of the rice weevil.

By spreading disease among the domestic live-stock, on which the cultivation of crops largely depends, insects indirectly affect human food.

The control of insects, therefore, should be a very important item on the programme of "Grow More Food" campaign.

All insects, however, are not harmful. The honey-bees, besides providing a wholesome sweet food, increase the yield and quality of fruits by pollinating the flowers.

6. Dr. M. L. Roonwal, Benares Cantt., (*Communicated*).

The study of birds and mammals to augment the source of food-supply consists in the improvement in the various breeds of poultry and cattle and in bringing home to people the value of animal food. That is primarily the business of the animal husbanry, dairy and medical men. The second aspect is the zoological

one and consists in assessing the economic value of these animals specially in relation to agriculture. To know which birds should be protected and which destroyed involves long and laborious study of the food-habits of Indian birds, regarding which we have today very little detailed information.

The migratory birds like the ducks, geese and snipe constitute an important source of food among the people of certain areas. At the same time the ducks and geese destroy young paddy in the rice-growing areas of Bengal and Assam. If we know more than we do at present about their migration-routes and their migration-biology we could supply suitable resting places for them and protect them by preventing indiscriminate killing.

As the relation of birds to agriculture is in no way less important than that of insects, for the study of which there are already a large number of centres, a central ornithological institute is an urgent necessity.

In countries like the U. S. A. and Germany work on the lines outlined above has been carried out with conspicuous success for the last half a century.

7. Dr. K. B. Lal, *Cawnpore,* (Communicated).

The production and preservation of food is profoundly affected by the activities of insects, both injurious and beneficial.

There is no crop which is not attacked by insects. For example, the sugarcane is attacked by borers and pyrilla, paddy by the gundhi bug, apple by the woolly aphis, codling moth and the San Jose scale, and mango by the mango hoppers and scale insects. Termites and locusts prove a veritable scourge for the cultivator. In storage, cereal grains, flour and dry fruits are all subject to serious damage by weevils and other insects. Damage is also caused by the injection of toxic substances into the plant tissues, or because the wounds caused by insects provide ingress to fungi and bacteria or by the transmission of virus diseases. Effort in the production of food is impaired by the diseases caused by insects in human beings and domestic animals.

Methods of controlling pests include the use of insecticides, the employment of mechanical devices, the growing resistant varieties, the manipulation of various cultural practices, and the utilisation of the natural enemies of pests. Methods for biologically controlling the borers of sugarcane and the woolly aphis of apple are under trial in many parts of India.

Insects as pollinators of flowers assist in better fruit setting. The introduction of honey bees near fruit trees or other crops has increased the outturn, besides providing honey as an article of food.

Investigations are now being launched in the United Provinces, for developing the bee-keeping industry under a scheme of the Imperial Council of Agricultural Research.

8. Dr. D. W. Devanesen, Madras, (*Communicated*).

Various Provincial Governments are giving their attention to the augmentation and protection of our marine and freshwater fishery resources. The biochemical aspect of the food problem lacks attention. With the help of the University and College Laboratories, Food-Charts can be produced to inform the public about the vitamin contents, percentages of protein, fat, calcium, magnesium, phosphorus, iron and copper present in each kind of sea-food, such as fish, oysters, clams, crabs and shrimps. The necessity for starting canning of sea-food is emphasized. Propaganda work on the importance of sea-food in the dietary, by means of leaflets in vernacular, is necessary to popularise sea-food.

VII. CORRELATION OF STONE AGE CULTURES IN INDIA.

(*Sections of Anthropology and Archaeology.*)

Dr. A. S. Kalapesi, presided.

1. Mr. P. Deraniyagala, Colombo, opened the discussion.

Investigation might reveal that many of the so-called stone age cultures of India are merely isolated fragments of one or two culture phases. Little is known about the stratigraphy and paleontology of our pre-historic sites, but the presence of hippopotamus fossils in North India and in Ceylon, and their absence from below the Godavari river to Cape Comerin suggests that geological conditions such as sandstorms, floods and redeposition have obliterated, severed or isolated into different parts what was once a single culture phase. The similarity of the *Soan* to

the *Ratnapur* paleoliths of Ceylon was stressed by me at the 27th meeting in 1940, and in 1943 a similar claim has been made for Burma. Neither the hippopotamus nor this human stone cult could appear independently in North India, Burma and Ceylon respectively, and all three countries apparently reveal fragments of one culture phase. This is only one example of what a reinvestigation of our pre-history will lead to, and for this purpose a committee of geologists and anthropologists interested in pre-history is necessary, for dealing simultaneously with stratigraphy paleontology and typology. This committee should (*a*) be a reference committee to whom all new discoveries should be reported (*b*) compile rules of publication and terminology for use by Indian pre-historians (*c*) re-study and correlate the known pre-historic sites grouping them into complexes, components, foci, aspects, culture phases, and patterns (*d*) decide who was the original describer of each Indian pre-historic culture. In conclusion I wish to stress the importance of studying the Pleistocene deposits of India which are a vast storehouse of knowledge unrevealed, of human and animal evolution and radiation to other countries, such as Africa and Malaya.

2. MR. D. SEN, Calcutta.

The problem of correlating palæolithic cultures is to be first solved. We have to view the problem from different standpoints—stratigraphical, typologic and palæontological. The geologist and the palæontologist should seriously take up the study of the Pleistocene geology of India, particularly the implentifroces. deposits and help the archæologist in dating the cultures. I may mention that geologists who are interested in pre-history should take up the problem of dating particularly the Boulder conglomerate, and the laterites from which the most of the earlier cultures come. In North India, the stone age cultures have been fruitfully correlated with the glacial cycle of the Himalayas This correlation should be re-examined in the light of more recent discoveries and observations. We have to find out whether this kind of correlation can be carefully applied the cultures of the Peninsular India.

Typologically we should be very cautious in the application of nomenclatures. Many workers in the field have taken after the European nomenclatures. I think it should be better if we evolve Indian nomenclatures for the cultures and use local names to avoid confusion. We can afterwards usefully compare the different cultures of India with those of Europe or Africa.

I would strongly suggest that the study of palæolithic and neolithic cultures be taken up on a regional basis and then results of our work be correlated. Only then it would be possible to reconstruct the stone age history of India as a whole. It is no use if we work in isolated manner without knowing other workers investigating in different fields. Only trained men should be allowed to excavate. Untrained amateur works should be definitely discouraged. And a scientific and co-operative outlook is to be cultivated.

Pleistocene geology and archæology have been in a way no man's land..' The time has come when geologists and pre-historic archaeologists should put their heads together in the study of the pre-historic past of this great sub-continent.

I would suggest the formation of a central body or a society consisting of experts who shall correlate and co-ordinate the results of the workers in the different parts of India with a view to fill up the gaps in the culture continuity of the stone age India.

3. PROF. C. S. PICHAMUTHU, Bangalore.

Several speakers who preceded me and who are workers in the anthropological field, have appealed to the geologists to co-operate with them in helping to fix the age of geological formations in which implements have been discovered in various parts of India. I realise the great importance of this type of co-operation, and I am sure that this would be forthcoming if anthropologists would seek the assistance of geologists on specific problems of correlation. Pleistocene and Recent formations are comparatively more difficult for purposes of correlation, but a person trained in geological methods should be of great assistance.

The question of the age of laterites was referred to by one of the speakers. This is again a difficult question. In Travancore State, for instance, two types of laterite have been recognised according to their mode of origin. What are known as "residual" laterites overlie the crystalline rocks, and are merely a very characteristic, weathering product of the Tropiss. Very similar in appearance to these laterites are the "sedimentary" laterites which constitute the topmost bed of the Warkalay Formation, and are more than 40 feet in thickness in places. It would be impossible to compare the ages of these two types, for one type has been formed from the top downwards, and the other from the bottom upwards.

In Mysore State, a collection of stone implements was made by the late Prof. P. Sampat Iyenger, and a description of some of these implements has been published by my colleague, Mr. K. Sripada Rao in the Mysore University Journal. The artefacts, however, were not found *in situ* in any lateritic or sedimentary bed and correlation is therefore not possible.

I agree that this question of the correlation of stone age culture is of great importance in India, and I trust that with the collaboration of anthropologists and geologists in ever increasing measure, a step towards the solution of this problem will be made.

4. Dr. A. Aiyappan, Madras.

In the task of correlation of stone age cultures of India very helpful data can be obtained by studies of the lithic cultures of our neighbouring countries such as Ceylon, Java, Malaya, Burma, etc. The exploration of caves undertaken by the Colombo Museum has brought to light the microlithic and neolithic cultures of Ceylon of which little was known previously. Recent work in Burma has given us more information about the nature and distribution of the Soan culture. We have to find an explanation for the close parallelism between the axe cultures of S. Africa and of Madras. It is suggested that rock-shelters and caves, such as those of Kurnool, should be excavated as early as possible. Excavation of implementiferous soil at the base of sand dunes such as those at Sawyerpuram is also likely to be extremely useful. At Manjankaranai and other lateritic sites, sections with a succession of implementiferous layers are seen which geologists should examine more thoroughly.

VIII. ETHNOLOGY IN INDIAN MUSEUMS.

(Sections of Anthropology and Archaeology.)

Mr. P. E. P. Deraniyagala, Colombo, presided.

1. Dr. A. Aiyappan, Madras.

In their report "Museums of India" (London: Museums Association, 1936), Markham and Hargreaves state that the majority of Museums in this country "either completely ignore the subject [Ethnology] or have a few ethnological exhibits in industrial or archaeological collections. This is all the more regrettable *as nowhere in the world are there greater opportunities* for procuring representative and complete records of races still in all stages of cultural development .... unless the collection and preservation of material to illustrate their present condition is undertaken without delay, *the opportunity will be for ever lost.*" Scientists have long been impressing upon the Government the need for ethnographic collections and an ethnographic survey of India. In *Man*, No. 113 (1901), p. 137, will be found printed the letter written to the Government of India by Sir Michael Foster, K.C.B., F.R.S., President of the British Association and a reply thereto from the Government of India in the Home Department (Public). (Proceedings dated, Simla, 23rd May, 1901.) Sir Michael Foster, after requesting the Government of India to obtain "a series of photographs of typical individuals of the various races, and if it should be possible, of views of archaic industries" etc., suggested, "This ...... would be the commencement of an Ethnological survey of India, similar to, and certainly no less important than the Archaeological Survey, of which the Government of India may so justly be proud." Provision was actually made in the plans of New Delhi for an Ethnological Museum, but the project still hangs fire! It is high time for an Ethnological Survey of India to be organized and the Ethnological Section of the Indian Museum now under the Zoological Survey to be enlarged into an Ethnological Museum which will be worthy of India and fully representative of the culture of its various tribes and castes, and also of some at least of our neighbours across our frontiers. This is a piece of scientific service to be undertaken by the Central Government, possibly in collaboration with the promoters of the proposed Asiatic Museum in London.

Very few provincial museums now have an Ethnological Section. Those that have a special section and have an ethnologist on the staff confine their attention, as a rule, to the tribal cultures within their provincial borders. In the Madras Museum, for example, the need is often felt for extra-provincial ethnographic objects; but there is no easy means of getting them; it is not even possible to know what collections exist in the various museums, as guides or catalogues of ethnological material published in India can be counted on the fingers of one hand. The only way out of this difficulty is that catalogues or at least lists of ethnological

collections in each museum should be made available for reference to all museums interested in the subject and an exchange service organised without delay. It should be possible also to appoint trained ethnologists on the staff of all the major provincial museums, e.g., Bombay, Hyderabad, Lahore, Lucknow, and Nagpur, to carry out this urgent work of collection and classification. Messrs. Markham and Hargreaves recommended the appointment of an ethnologist in the Indian Museum to deal with the uncatalogued and unpublished collections. No one will deny that the present staff in the Ethnology Section of the Indian Museum is extremely inadequate. Anthropologists should put in a strong plea to the authorities immediately to rectify this deficiency.

The average Indian (including several museum workers) does not sufficiently appreciate the great interest that the rapidly disappearing folk culture has for posterity. We are, most of us, ashamed of our aboriginals, and our peasantry, but nations with greater appreciation of the subject have their folk museums, e.g., those at Moscow, Copenhagen and Stockholm. Grierson's "Bihar Peasant Life" is a very good survey of the folk culture of that province. It is a matter of great regret to me that no similar survey has been made of the Madras Province. The enterprising and vigilant ethnologists can and should rescue from oblivion such items of folk culture as are fast becoming mere names. To cite one example, the industry and vision of the authorities of the Colombo Museum brought to light the existence of numerous caste flags and insigniae of which in the Madras Province there are few survivals and of whose existence there are only references in literature.

The teaching of anthropology is becoming increasingly popular in Indian Universities and it is hoped that the exhibits in university museums of Ethnology will be displayed on an evolutionary or culture-historic plan, as is successfully done in the Pitt-Rivers and the Horniman Museums. Though the arrangement of ethnological exhibits in most of our museums will have to be geographical, better use should be made of the psychological device of comparison and contrast. The pros and cons of exhibition methods are fully discussed by W. H. Holmes in *J. R. A. I.* (1902).

Ethnological exhibits in Indian Museums enjoy very great popularity with the visiting public. In England, they are second in popularity only to the Egyptian collections. If there has been neglect of Ethnology in Indian Museums, the public or the administrations cannot be blamed for it, for anthropologists have not approached them yet for support in any organized fashion. Archaeology is fashionable in India and is encouraged because of the powerful stimulus given to it by Lord Curzon. While archaeological sites can be protected by the Government, it is obviously impossible to conserve for posterity the rapidly vanishing folk and tribal cultures. Hence the need for ethnographical museums is most urgent and imperative. Every day of delay in collecting in this field means the irretrievable loss of material for which posterity will justifiably blame the present generation.

2. Mr. R. Vasudeva Poduval, Trivandrum.

The study of Ethnology has suffered some neglect in recent years probably, because of the lack of encouragement which it used to receive under the auspices of Government before. The ethnological collection in most of the Museums in India deserves to be considerably improved. In Travancore, however, an attempt has been made in the preparation of Plaster cast models of the rapidly disappearing hill tribes of the State and of displaying them in the State Museum at Trivandrum which contains a comprehensive collection of jewellery and musical instruments. Each Museum should ordinarily concentrate in the collection and display of the specimens of the district or linguistic area, which it represents and make it sufficiently full and representative of the culture of the people for whom it is intended.

Secondly, it is highly necessary that the Museums Association which was formed about 1937 should begin to function and discuss subjects of common interest.

Thirdly, steps should be taken for the starting of a journal of Indian Museums where subjects relating to museology should be treated. I would also suggest the establishment of a central institute for the encouragement of the study of Anthropology, Ethnology and Archaeology and would urge that a resolution should be passed at this meeting of the section of Anthropology and Archaeology on the subject and forward it for necessary action.

3. Jyotsnakanta Bose, Calcutta.

In India Museums are thought of as curio houses. The term 'yadughar' which is used in Bengal for the Indian Museum literally means 'magic house'. This expression amply illustrates the idea of the people about the museum, and for this the museum authorities are responsible. Now-a-days the objects of a museum as

illustrated cannot be commended. The object of a Museum should be to illustrate the specimens in such a way that an ordinary man can easily get an idea from it directly from observation with the help of its labels. In India where there are about 25 millions of aborigines we have got very few museums with suitable provision for study of these tribes and others. Ethnological objects are generally huddled up in a gallery.

Ethnological museums should be developed into two groups--Provincial and District. The Provincial Museum should be arranged in geo-ethnic basis and its function will be to train men for the collection, preservation, exhibition and Museum organisation etc. The District Museums, on the other hand, should be arranged on the lines of culture history method and it will represent the collection of the district. The Provincial Museum will also conduct researches for the improvement of a people. They should also send suggestions to the authorities for the proper development of the tribal people.

IX. METHODS FOR IMPROVEMENT OF YIELDS OF PADDY.

(Section of Agricultural Sciences.)

RAO BAHADUR DR. D. V. BAL, Nagpur, presided.

1. DR. S. P. AIYAR, New Delhi.

The average yield of rice in India is very low compared with yields in countries, such as Japan, Spain and Java. This is accounted for on the basis of climatic and other factors based on latitude as well as industrial and scientific development, and partly on the basis of the high proportion of poor land used for rice growing in India. The methods suggested for the improvement of yield are the development of high yielding varieties by plant breeding methods, improvement in the water supply, control of pests and diseases, and the application of appropriate fertilizers. The various factors that control the yield are light and temperature, water supply, soil, nutrient elements, varietal response, and the methods of cultivation. In the fields, factors may not be controlled in full and the results of manurial experiments may not be successfully repeated in large-scale farming. The superiority of ammonium sulphate over all other forms of ammoniacal or nitrate nitrogen in respect of the paddy crop is stated to be due to the sulphate ion present in it. This view is further supported by a discussion of the special significance of sulphur in paddy nutrition.

The active participation of agricultural chemists is stated to be essential not only to discover the nutritional requirements of the crop in relation to the soil but also to suggest suitable treatments. The failure of potassium in the tropics in modifying crop yields has been noted and the necessity for further research on this as well as other nutritional problems is indicated. Liming is considered to be unnecessary or even harmful to paddy. In recommending a countrywide application to the paddy crop of ammonium sulphate and superphosphate as a wartime measure, it is to be noted that there is great difficulty in obtaining supplies.

Certain suggestions for improving the usefulness of agricultural experiments may be given. A proper soil map is stated to be essential to permit extending the experiments to larger areas. Pot experiments together with soil and crop analyses will be economical methods of discovering the manurial requirements of the soil.

2. DR. SUNDER LAL HORA, Calcutta.

He explained how in special areas, such as the Sundarbans, where water remains standing in the paddy fields throughout the crop season to a depth of 9″ to 12″, it is highly advantageous to introduce the young carps for culture. The fish eats the weeds and thus the cost of weeding is saved. the fish eats injurious insects and thus keep a check on the insect pests of paddy while their movements through tillering action induce more shoots to come up thus resulting in the better yield of the crop. The fish excreta acts as manure for the paddy plant. The fish gets plenty of space to move about and plenty of food and thus fattens well within a short time. From the experiments carried out on a field-scale at Gosaba, it is clear that besides fish as a by-product the actual yield of paddy can be increased by 10—15%. Thus agriculture and pisciculture can be worked as correlative industries.

He stressed the point that this method is greatly in use in Japan and was subsidised in the earlier stages by the Government by the means of free distribution of fry.

It has been definitely ascertained that the crop is not damaged.

In reply to questions Dr. Hora stated that shallow waters of the paddy fields act as nurseries for the fish and contain always sufficient air for the proper respiration of fishes. In Bengal there is a well established fish fry trade so there is no difficulty in buying fry for introduction in paddy fields.

3. DR. S. M. SIRCAR, Calcutta.

War stopped the import of rice from Burma, and the consequences were reflected partly in the shortage of this essential food grain in Bengal in 1943. We might trace the reason for the notorious Bengal famine of 1943 in the fact that Bengal is not self-sufficient in rice and has an annual deficit of more than 2 million tons of rice. Population of the province has increased more than 25% in 20 years while the yield of paddy during the same period has gone down more than 20%.

The main factors controlling the yield of rice are supply of water, manures, seeds, pests and diseases and lastly the method of cultivation. Unfortunately proper attention to all these factors is absent in the cultivation of paddy. In this province not more than 6% of rice area is supplied with improved seeds, although the provincial Department of Agriculture since its creation is turning out new varieties which give greater yield. Water requirement for this important crop is altogether neglected; it is grown at the mercy of rain water which is very uncertain and untimely. Sowing of rice is often delayed for want of rains and later excessive rain destroys a ripening crop. This dependence on rain water should be removed by irrigation and arrangements for drainage should be made. In India irrigation is generally done without regard to the actual water requirements of rice. It is suggested that in schemes of irrigation water requirements of different varieties of rice grown under different environmental conditions should be determined. This would help in ascertaining the suitable extent of time and the amount of irrigation water necessary for a particular variety. The latter can be considerably reduced by the correct choice of the time of application.

Regarding the applcation of manures it is suggested that both organic and inorganic manures should be used. For maintaining the fertility of soil artificials should be added from time to time. The countries obtaining higher yield has accepted a general policy of using artificial manures. Application of manures should be based on the requirements of different varieties of rice under different environmental conditions, so the nutrient requirement of a variety should be ascertained first, then the proper quantity of manure applied. Time of application which has got a great effect on yield and also on the total quantity of manures required, is to be determined for each variety. For increasing the yield of rice phosphate fertilisers should be used as soils in Bengal are deficient in this element. Without phosphate, nitrogen in rice fields obtained either by fixation from atmospheric nitrogen or by the addition of manures does not increase the yield. In absence of phosphorus, nitrogen absorbed remains unmetabolised and there results a failure of grain formation.

Attempts should be made to apply the technique of vernalization in rice cultivation. Earlier maturity and increased yield are the practical utility of this technique. In Russia the method of vernalization, having been worked out with temperate cereals, has been used in field practices with great success. Sufficient work to apply the technique to rice has not been done in India. That the process if successfully worked out holds out distinct possibilities of successful application in agricultural practices in India has been demonstrated in my preliminary experiments on vernalization of rice by photoperiodic treatments. Short days of 8 to 10 hours by cutting off the excess sunlight were given to rice seedlings, aged one week, for 4 to 6 weeks in the seed bed, then the seedlings were transplanted in pots. As compared with the untreated plants an earliness of two weeks and increased yield of 16 to 20% were noticed in the experiments performed by me. This method is applicable to the varieties of rice grown in the field after transplanting as the supply of short day light to seedlings in seed bed does not entail any practical difficulty to rice growers. It appears that this would be a suitable method for inducing earliness and increased yield of paddy.

X. SCIENCE AND PRACTICE OF SOIL TILLAGE IN INDIA.

(Section of Agricultural Sciences.)

RAO BAHADUR DR. D. V. BAL, Nagpur, presided.

The discussion was led by Dr. B. Viswa Nath who reviewed tillage experiments carried out throughout India and said that deep ploughing was not necessary except

under special conditions. Deep ploughing once in five years to break up the subsoil can be said to be beneficial. As the organic contents of the Indian soils as a rule were low and deep ploughing helped in the rapid decomposition of this small store, the good results of deep ploughing observed in temperate climate were not seen in the tropical climate of India. Dr. Puri, Rai Bahadur Jaichand Luthra and Rao Bahadur Dr. D. V. Bal agreed with the main theses of the discussion and quoted their experiences in support of this hypothesis.

Rai Bahadur J. C. Luthra, Lyallpur.

Age-long practice followed by peasants in India has been to plough the land as many times as possible for preparation of sowing various crops. There is a well-known maxim that the more ploughing is done the greater the yield, but recently the view has been changed as a result of experiments carried out on agricultural farms that repeated ploughing is not necessarily conducive to more yield. What is actually required is that fine tilth should be produced before seed is put in. The extent of ploughing must vary with the kind of the crop. Deep-rooted crops, such as cotton, require better tilth and more ploughing. On the other hand, gram does not need such treatment. One or two ploughings are the utmost that are given to this crop. In the case of rice, off-season cultivation has been found to depress yield. Old notions of farmers may be correct in certain ways but in one respect they must be definitely told that more ploughing, however long it may be, cannot increase the yield. What is most important is the maintenance of fertility either by adding manures or adopting proper rotation. By continuous cropping soil is depleted of nutrients. This must be replenished. Opening up of the soil alone would not help for this purpose. The problem of soil tillage is, therefore, to be approached in several directions, *i.e.*, texture, suitability for the various crops, fertility and methods of securing it.

(Authoritative summaries of all speakers could not be obtained).

XI. FOOD ECONOMICS.

(Section of Physiology.)

Dr. S. N. Mathur, Agra, presided.

1. Mr. K. Mitra, Patna, opened the discussion.

Food Economics may be defined as the subject which deals with the methods that can be employed to exploit the resources of any country for maximum production of food and to utilize to ensure distribution and consumption of same in such a way that the people as a whole may gain and maintain health and immunity from diseases.

Economists, agriculturists, physiologists, public health workers, and animal husbandry experts have after independent investigations come to the one and same conclusion that India does not produce enough food to support her population and livestock even at the lowest level of health and efficiency. The speaker does not feel competent to discuss the various factors, *e.g.*, poverty of soil, uncertainty of rainfall, fragmentation of land, unplanned cultivation or insufficiency of cheap fertilisers, etc., which are responsible for poorer agricultural production in this country as also to scrutinise the various methods that have been advocated by scientists and social workers alike to remedy the existing defects. But one need not pretend to be an expert to state that scientific knowledge and technique yet remains to be utilized in production of food and fodder. Only last week, the head of the Chinese Agricultural Mission, Dr. Pan was reported to have stated that in China the production of rice and wheat per unit area of land is almost twice as much as that in India.

In the matter of planning food production, the physiologist has to play a very important role. He has to calculate in terms of the different items of food the requisite quantities for both the human and the animal population. It is an axiomatic truth that in a pre-eminently agricultural country the human nutrition workers cannot afford to ignore the problems of cattle nutrition. In any geographical unit where both the human and the cattle populations have to live upon the produce of the land, the existence of malnourished cattle is a serious menace to any movement for the betterment of the health of the people. At present in this country there is a regrettable lack of contact between the physiologists and health workers on one side and the agricultural and animal husbandry experts on the other. This deplorable state of affairs should be mended and greater *liaison* established. Another serious drawback in the matter of planning is that no reliable or reasonably accurate statistics pertaining to the production of the

essential edibles, such as milk, meat, fish, vegetables, poultry, etc., are available. The accuracy of crop production figures are not beyond reproach and published reports do not include all food crops produced. This defect deserves the early attention of the agricultural experts.

Another aspect of food planning in which the physiologist can be helpful to the producers and consumers is in the subject of 'substitute foods', particularly during this present food crisis. There are quite a large number of tubers which can replace cereal element in the dietary in times of scarcity. Some of these tubers are very mealy ones and can be grown with a little effort in the kitchen garden and in areas which are not under cultivation.

In drawing up the programme for planned production fullest advantage should be taken of the findings of the physiologist in the laboratory. Except intelligent guess work from 'in vitro' or animal feeding experiments, not very adequate scientific information exists as to the relative nutritive value of the different cereals and pulses consumed by large sections of people in this country. 'Should Soyabean be grown in preference to common pulses?' or 'Should the vegetable oils be hydrogenated and then consumed' are some of the problems which have not yet been solved satisfactorily and demand serious notice of the physiologists. Undoubtedly some amount of valuable work in this connection has been done by the nutrition worker but a good deal remains unfinished yet. Efficiently staffed and well-equipped centres of research should be opened for each of the provinces and States in India to deal with these urgent national problems. Mention may be made of the fact that on grounds of popularity of vegetarian diets among a large section of people the sources of fish and meat foods have not been fully exploited. In actual experience of the speaker during dietary survey of thousands of families it has been noticed that people with no objection to fish and meat have been forced to live on a vegetarian fare because either the meat foods were not available locally or the same was beyond the purchasing power of the consumers.

It cannot be denied that with the rise of the economic status the standard of food is likely to improve. But it is also true that in the absence of an efficient marketing organisation even increased food production or increase of purchasing power cannot raise the standard of food intake to the expected level. During the recent food crisis in Bengal it became evident that by the time the food grains left the producers and appeared in the retail market the price soared beyond the purchasing power of the average consumer. The duties of the marketing organisation would be to place the essential foods within the purchasing power of the majority of customers at reasonable cost.

General principles of nutrition must be made popular knowledge through all the organs of publicity, so that substitute foods may be better utilised, particularly during the present food shortage. In view of the deficient dietary it is desirable that public health centres in collaboration with agricultural units in the different parts of the country should take up as an important part of their programme the education of people in the matter of growing more vegetables in the backyard of every household. This can be achieved with a little effort and practically with no expenditure, if the workers do not confine their activities to the distribution of leaflets and posters with a pious hope for the best results but they persuade individually the householders through personal contact. The lack of adequate vegetable quota noticed in the dietary of the people cannot be ascribed to poverty alone. There are millions of families in this country who can afford to purchase vegetable more generously and millions of others who can grow them with little or no expense if only they be educated in healthy food habits.

It is a common knowledge that at the height of their respective seasons, a large number of fruits are rendered unfit for consumption in this country while the average level of fruit consumption is notoriously low. This situation may be prevented by popularising knowledge on fruit preservation, so that fruits may be purchased when cheap and preserved for use by those families who cannot afford to pay for them in seasons of scarcity. Mention may be made of the fact that millets are not as bad as they are popularly supposed. Malting, which is a simple process can be carried out in every household does convert the millets into very nutritive foods. Every housewife, every health worker, every medical man or social worker interested in the care of children, and expectant and nursing mothers whether institutional or domicilliary, should learn more of the newer knowledge in nutrition so that the available food may be utilized to the utmost advantage.

2. Dr. A. M. Shirazi, Madras.

Lack of proper transport facilities in India is a factor affecting Food Economics specially with regard to the proper distribution of vegetable and fruits. The Railway may be approached for reducing the rates for these articles.

3. Mr. M. N. Rudra, Patna.

There should be State encouragement for growing more fish and preserving them so that the demands of an increasing population can be met in a planned way. In respect of the staple food, rice, it should be the duty of every physiologist, public health worker and nutrition worker to educate the general public and especially the housewife to cook and serve rice in such a way that no surplus cooking water is thrown away.

4. Dr. K. V. Giri, Guntur.

Next to agriculture and animal husbandry, fisheries constitute an important source of human food. It is a rich source of protein and the fish protein supplements the rice protein. It is a rich source of phosphorus, though low in calcium content. Although there is ample data available regarding the vitamin A content of fish liver oils, there is still scope for investigation on the vitamin A content of other fish liver oils and intestinal oils. Further investigation is necessary with a view to finding out good sources of vitamin D, vitamin B_1, and riboflavin among fish. India with its large rivers and sea coast surrounding the vast peninsula should develop fish food industry and attempts should be made to form a Central Research Institute for investigating the problems of fish as source of food.

5. Dr. B. Mukerji, Calcutta.

It is well recognised that dietary in most provinces in India is hopelessly deficient in cereals and protein. Fish culture can supply a deficiency of protein in the dietary very quickly, as has been already shown by a number of workers in Bengal. Fish culture in paddy field is being supported in Bengal and this policy may be usefully adopted elsewhere.

XII. THE POSITION OF PHYSIOLOGY AS AN INDEPENDENT SCIENCE.

(*Section of Physiology.*)

Prof. A. V. Hill, London, presided.

1. Prof. B. Narayana, Patna, opened the discussion.

At the outset, I must thank the President for having selected this important subject for discussion at the Congress Session. The discussion is specially appropriate in view of the presence of Prof. A. V. Hill in our country.

I remember just 7 years back from today when Col. Bhatia presided over the Section of Physiology at Hyderabad (Deccan), he conveyed to us messages of greetings and encouragement from abroad and amongst those was one from Prof. A. V. Hill. The latter said "At Cambridge, as you know, physiology is just respectable as physics. It is certainly just as difficult as physics. Claim for it an independent and honourable place such as physics has. Do not let it be just as a handmaiden (as the old saying was) of medicine. Physics is not the handmaiden of engineering. If it had been, engineering would be in a bad way, for modern engineering depends upon physical knowledge and physics would have made no progress if it had been the handmaiden of any other science or art. Independence and an honourable position are required and if you can help to give physiology in India these you will get first-class youngsters in to join it".

The above remarks made by Prof. Hill are very apt and should leave no doubt in our mind that physiology must have an independent position just as chemistry or physics has. We must also realise that no progress in physiology is possible unless such a position is acquired.

Strictly speaking physiology has a dual position—it has its position as a pure independent science and it has its position as a science applied to medicine. The application of physiology to medicine is undoubtedly of value but it is its unique position as a pure independent science which is of real value to the advancement of physiology in this country. Unless physiology is made independent as a science it is bound to stagnate. It will fail to attract good workers, its progress will be hindered greatly and for all times to come physiology will continue to be a subject subordinate to medicine.

We all know that physiology stands between medicine on the one hand and physics and chemistry on the other. Unless independent research work grows, devoid of any idea of its applications to medicine, no real scientific advance in physiology is possible. Then again, if we think of physiology only in terms of medicine, we will necessarily have a limited number of workers solving problems on applied physiology alone and physiology as a science will never grow.

We all know that the universities of Great Britain, in those on the continent of Europe and in the United States of America, physiology has already gained an independent position. No body there thinks of physiology as a part of medicine but as one of the important science subjects. A student can study physiology for a medical degree or for a general science or research degree at these universities. The door to the science of physiology is open to all and not confined alone to the students of medicine. The question now arises as to what is its position in India. It is entirely different here. The teaching of physiology is being done in most of the Indian universities only as a part of medical education. The only place where physiology as an independent science subject received recognition very early was the Presidency College, Calcutta. I must admit it was due to the efforts of my esteemed teacher Prof. S. C. Mahalanobis that the department was started. The department was a well-equipped one and imparted teaching up to the I.Sc., the B.Sc. and the M.Sc. standards. Only such students were admitted as were studying physiology as a pure science subject and not as a part of medicine. A few years later a postgraduate department of physiology was opened at the University College of Science, Calcutta. The Calcutta University naturally attracted quite a good number of students who wished to study physiology as a purely scientific subject. The other universities in India did however make arrangements for teaching physiology for a science degree but to a few students only off and on but did not actually start an independent physiology department for science students. Physiology remained neglected to a great extent.

It is high time that the teaching universities in India started their own departments of physiology and that those universities which were not teaching universities impressed upon their local Governments to introduce the teaching of physiology in Science Colleges. An easier solution possibly may be to strengthen the existing physiology departments in the different medical colleges and schools in India by enlarging the staff, by undertaking teaching of physiology for science degree at these places, and by encouraging young graduates to engage in research work. Special scholarships and fellowships should be created by the universities on a lavish scale and enough funds should be placed at the disposal of the professors for equipment.

With the growing importance of nation's interest in the maintenance of health, I would also like to point out that initiation into the working of the human body may be started at an earlier stage in a student's career, namely, the school stage. Elementary knowledge of physiology to a young student will create in him a lively interest and it is certain that a good number of students, who get interested in the subject at an earlier stage, may like to study the subject for their science degree.

I may mention here that some improvement in the position of physiology teaching and research has taken place within the last two decades. The teachers of physiology formerly used to be either a clinical physician of the hospital or one who was a part time worker. Conditions have changed since then. We are now having full-time professors debarred from private practice to enable them to improve the department and stimulate research work. But this is not all. The department should be further strengthened by appointing whole-time lecturers and assistant professors. Then again, the staff of the department of physiology should be attractive to bring good people in the department and adequate compensation given in lieu of private practice.

At this stage I would refer to the recent report of the Physiological Society of Great Britain to the inter-departmental committee of medical schools. Their recommendations are that honours physiology B.Sc. scholarships and post-graduate scholarships and fellowships be created. Inquiry into salaries should be made. There should be established more readerships and associate professorships. There should be co-ordination between physiology departments and hospitals, physical education departments and public health departments. The staffs of physiology department should be increased and provision of building and equipment for teaching and research made. Attention should be given to the wider functions of physiology in relation to general education and communal health. I wish these recommendations were adopted here also.

Lastly, I would suggest that a committee of the Physiology Section of the Indian Science Congress Association be formed to critically scrutinise the position of physiology in India and make recommendations to the different universities.

2. Col. S. L. Bhatia, Delhi.

I had referred to this subject in my Presidential address to the Physiology Section in Hyderabad in 1937. I am entirely in agreement with Prof. Narayana's views.

There has been a marked improvement in the status of Physiology in Indian

universities during the last 20 to 25 years and the subject is gradually coming into its own. The subject does not merely form part of the medical curriculum, but in the Universities of Bombay, Madras and Calcutta it is a subject for B.Sc., M.Sc., and even Ph.D.

We need first class teachers of Physiology (professors and assistants) who should be well-paid. This would improve the status of the subject. Apart from it being an important preclinical subject, it is an important subject which should be taught as an independent science.

In India, there is a need for physiologists to deal with problems of nutrition, which is an all-important problem of the day, and has important bearing on the welfare of the people.

The universities should realise the importance of Physiology, and give it its rightful place in the system of education in the country.

3. Dr. (Miss) Eleanor D. Mason, Madras.

A valuable contribution of physiology is that it draws students into thinking in terms of actual experimentation instead of mere description. When laboratories are vigorously in action they attract public attention and the science begins to win a place on its own merits.

4. Mr. Gopal Krishna Ghosh, Patna.

The public also should be made to realise the importance of physiology as an independent subject. In India, physiology is usually taught as an appendage to clinical medicine and surgery, and the teaching in physiology is usually regulated by clinicians. Subjects treated like this cannot develop.

5. Dr. M. Damodaran, Madras.

The reason for the backwardness of physiology in India is the lack of opportunity for successful careers for pure scientists in general in the Government Departments of Medicine, Engineering, Agriculture and the Veterinary Department. The teachers of chemistry, physics, physiology, etc., in Medical Colleges, if they are non-medical men, have very poor chances of promotion or of occupying responsible post commensurate with their qualifications in their special subject.

6. Dr. (Mrs.) Margaret Stewart Munday, Delhi.

Physiology is a neglected subject as far as women are concerned. It is very difficult to obtain trained worker and teacher because financially it is unattractive. The subject is of value not only because it deals with the problems of nutrition but also because physiological technique may be employed in order to lay down the standards of health for industrial workers and also for conditions in the factories. It may also be employed for reassessing physical standards, which are mainly based on European and American figures, as applied to Asiatic countries.

7. Mr. K. Mitra, Patna.

Whilst agreeing with Prof. Hill that public opinion should be created, I feel that our medical men should be educated into the subject of 'what physiology stands for'. At present there is very little or no liaison between department of physiology and that of public health. As a result of this deplorable state of affairs no satisfactory physiological methods for grading of health have yet been developed neither in India nor abroad. The work at Peckham Health Centre has amply demonstrated that person may not be called definitely ill and yet may not be in perfect health. As a consequence such people do not come under the observation of practising physicians or of health workers. This point was stressed by the P. E. P. report of Great Britain. Physiology of health needs greater attention of clinicians and health workers and this can be achieved if medical men and others broaden their present narrow outlook on the subject of physiology.

8. Dr. B. C. Bose, Calcutta.

Regarding the question of educating the mass in physiology the following two points are important—

(1) Introduction of elementary physiology courses in the secondary schools as exists in France, Great Britain, etc.

(2) Regular programme of broadcasting popular talks on physiological subjects by physiologists.

9. DR. BAL RAJ SINGH SAHNEY, Lucknow.

To educate the public frequent demonstrations of physiological interest for the public may be arranged to create enthusiasm and interest in the masses. As an example, the Medical exhibition held at Rangoon in 1938 and 1939 produced remarkable results of great educational value.

10. DR. N. K. BASU, Delhi.

Difficulties faced in framing the syllabus of physiology and hygiene for the Delhi Board of Higher Secondary Education were placed before the meeting.

XIII. MENTAL LIFE AS PICTURED IN CONTEMPORARY PSYCHOLOGY.

(Sections of Psychology and Educational Science)

MR. JOHN SERGENT, New Delhi, presided.

1. DR. N. N. SEN GUPTA, Lucknow (communicated).

British physicists of the 19th century attempted to represent abstract laws in terms of concrete models which can be seen and handled. According to Sir Oliver Lodge "we cannot form a complete mental picture of the actually occurring operations" so long as we adhere to abstract formulations of laws. Rey, a French Physicist, supports the same principle when he says: The hypothesis which is fruitful in the physical realm is of necessity an imaginable hypothesis, one constructed in terms of perception and sensation. Physics has probably been outgrowing this notion. Fruitfulness of the principle of models for the purposes of comprehension of the basic ideas of a science and of suggesting new lines of work, however, cannot be denied.

Psychological theories are, from the nature of their subject matter, incapable of adequate representation by mechanical models. Yet the motive of models has long been working in the mind of psychologists. It is true that no psychologist has ever constructed an actual model as physicists have done. The picture of models was nevertheless perpetually before their mind when they attempted to describe the mutual relationship among the mental states. Attempts at such representation were prompted as in the case of the physical sciences by a two-fold motive: (*i*) Comprehension of mental life as a working reality; and (*ii*) suggestiveness of the scheme for further investigation.

Success of all such representations, however, has been adjudged in the physical sciences in terms of their adequacy in subsuming under them a large range of observed facts and by their fruitfulness for further investigation. The same critique should be applied to the various schemata adopted by psychologists.

We shall discuss the various *representations* adopted by psychologists for an adequate comprehension of the mental personality.

(*i*) The early attempts in Western thought was to represent the mental life as a plane surface which could be divided into as many sections as there were mental functions. This is instanced by the Pythagorean doctrine of parts of the soul, Reason, Will and Desire. Plato proposes that each of these divisions may further be subdivided and that each possesses a dynamic character, desire, and a principle that may increase its dominance, pleasure. Some of the type-psychologists are not averse to adopting such schemes.

(*ii*) A genealogical tree is often adopted as a scheme for representing the mental functions. The soul often stands at the apex from which other mental functions issue forth as progeny from ancestor. Aristotle very largely adopts this method along with certain special notions pertaining to his system of thought. Functional psychology often lapses into this scheme. The Faculty Psychology very largely adopted certain variations of these two methods. These schemes were, however, complicated by the addition of several other notions. One of these was the notions of development, the idea that some of the mental functions were genetically prior to others. The other notion was that of combination of elementary psychic states into more complex wholes. We find both of these ideas introduced into the schemes of representation already mentioned.

(*iii*) We see the picture of a hierarchical arrangement often pyramidal in its configuration in the works of Brentano, Wundt and their circle. We begin with the concept of an activity at the top and gradually broaden out at the base in the rich variety of mental processes. We also read one or the other of these schemes (*ii*) and (*iii*) suited to the needs of the Factor School.

(*iv*) We see again the picture of a field of forces in manifold interaction and interlacing of the stimuli and the psychic responses. The several types of Dynamic

theory, the Gestalt theory, the Field theory of Wheeler and others, and Tolman's Sign-Gestalt theory impart a vivid meaning to this scheme of mental life.

(*v*) Lastly, there is a half articulate idea of mental life that seems to diversify itself into several dimensions. Lewin's Topology, Boring's partially worked out scheme and Brown's notion of social order are notable contributions in this direction. I have attempted to elucidate the basic idea of this scheme of mental life in a paper contributed to this section on a previous occasion as also in my Presidential address to the Indian Philosophy Congress in 1940. All the schools of recent psychology can thus be subsumed under one or the other of these schemata.

These *schemata* should be adjudged in term of four principles;

(i) *Principle of conformity with the known properties of mental life* :

(*a*) Mental states perpetually change,

(*b*) Mental states seem to influence one another often without undergoing any change themselves, as for instance in the relation between attitudes and dispositions and perceptions and ideas to which they are related, and

(*c*) they enter into various orders of relationship in which one may dominate over others or completely lose its identity. We may ask which of the schemata represents these properties more adequately.

(ii) *The principle of expansion* :

How far is a schema in consonance with the growing experimental data in the several fields of investigation?

(iii) *The principle of fruitfulness* :

How far does the schema suggest new problems of experimental and analytical observation?

(iv) *The principle of lucidity* :

How far is the schema capable of strict logical definition and mathematical or symbolic representation?

Very few of these modes of representation do justice to the facts that (*a*) mental states perpetually change, (*b*) mental states seem to influence one another and (*c*) they seem to enter into various relationships in which one may dominate over others or completely lose its identity. Other models have consequently to be devised for representing the variegated course of mental life.

The issues upon which we are to focus our discussion are *not* those of reality or unreality of any of these pictures that emerge from the experience, analysis and experimental data. We are called upon to consider today the following questions :

(1) How far the criteria suggested above are satisfactory for Psychology considered as a natural science?

(2) Assuming that these are satisfactory, which, if any, of the conceptions satisfies the criteria?

2. Dr. (Miss) K. H. Cama, Bombay.

Mental life cannot be conceived of as an independent process or entity. The neuro-muscular-glandular organism plays an important part in any aspect of mental life. It is a mistake to dissociate the mind from the physical body. It is only when we take the organism as a whole that we are able to understand mental life. The individual being a bio-physio-chemico-physico-psychological entity mental life cannot be explained without taking an integrative and synthetic or Gestalt view. Therefore both mind and body should always be considered together.

3. Dr. N. S. N. Sastry, Mysore.

Wundt started his laboratory in 1879, when psychology attempted at breaking away from philosophical moorings. Two points of view in psychology then became pronounced, (*i*) experience taken as content and (*ii*) experience as process. These points of view gave rise to the Behaviouristic point of view which looked upon all behaviour as mechanical. Consciousness was negated. Later a sort of reconciliation has been attempted between behaviourism and mentalism. Inadequacy of functionalism and structuralism gave rise to self-psychology—which according to Miss Calkins, is functional psychology.

Dynamism as advocated by Woodworth, hormonism of McDougall, Gestalt of the German School etc. have their own interpretation of mental life. Few examples suffice to show the picture they draw.

Learning as a process and an act of the dynamic mind as has lent itself into experimentation on a large scale. All learning, according to the Watsonians is to

be interpreted in terms of mechanical formation of stimulus-response connections. Such over-simplification has been brought out by the goal-seeking activity of the inner drive of an inherited type. The entire organism reacts. The interpretation of the learning is due to organised perception which endows the organism with insight.

Retention and memory depend both upon the methods of learning as well as on the attitude of the learner. Here is a faint possibility of reconciling the opposing schools of behaviourism and dynamic-hormonism. Personality itself is recognised as an organisation which is a result of dynamic interplay of inherited capacities and modifications by external stimuli. There is predetermination. Yet it is not a mechanical jumbling of habits associated. The psycho-analysts explain personality largely from the point of view of the cohesion of the conscious and the unconscious.

That there are certain innate capacities or determinants is accepted by most of the schools. But these are amenable to influences. Thus environment in the broadest sense, can and does influence the mind. All mental life is a function of the possibilities of native bents of reactions and the probabilities of external environmental stimulus streams.

4. Dr. I. Latif, Lahore.

Modern Psychology is a biological science rather than a branch of metaphysics. Its outlook is objective and experimental. It entrains strong misgivings with regard to the value of introspection which enjoyed great popularity with philosophising psychologists.

The modern psychology in its concept of mental life is bound to differ vastly from the conception of mental life as a mysterious and mythical process.

In opposition to this view, modern psychology emphasies the organic unity of the entire living organism; and thus tends to rule out of consideration the orthodox dualistic scheme of the mental and the physical. According to it, life in its concrete form is mental as well as physical. Mental life is an abstract, in modern psychology, whose main task consists in keeping in close touch with the concrete realities of life and metaphysical concept has no place in it.

Modern psychology is based on the postulate that mental life is rigidly governed by the law of causation eliminating accidental happenings. Strict determinism is essential to a scientific explanation of any phase of mental life.

The modern psychologists uses the term "mental life" in a comprehensive sense to include both the conscious and unconscious experience of the individual. Older psychologists had been using this term to denote only the *conscious* experiences of the individual.

Lastly, modern psychology treats of mental life as a dynamic behaviourial process rather than as a store-house of static categories of the mind.

5. Dr. Indra Sen, Delhi.

The various conflicting schools of Contemporary Psychology do involve a picture of mental life. The mental life, however, must be understood in its widest sense of human nature, expressing itself in experience and behaviour.

The various schools do, lack agreement even regarding the nature of the subject matter and the methods of investigation. But they all undertake a scientific study of the individual man as a whole. Evidently, with the unity of our basic subject-matter the man—kept in mind, it becomes easy enough to contemplate the behaviour of Behaviourism, Consciousness and Experience of the predominantly Introspective Psychologies and the Sub-conscious Psycho-analysis though so largely exclusively emphasized as complementary studies.

But is it possible to positively characterise by any qualities or features the unitary picture of mental life, which is involved and seems to be taking shape in Contemporary Psychology? This is exceedingly difficult, except in the sense that a few judgments, which have become widely influential with psychologists generally, could be offered as representative of the admitted truths of the different schools.

Hormism of McDougall is, a unified body of psychological knowledge, move largely by itself a synthesis of such judgements then a school like the others. At any rate, it is marked by the spirit of such synthesis.

As illustrations of such judgements I venture to offer the following:— (1) That Behaviour is a necessary part of the psychological subject matter. (2) That the objective methods of investigation have an indispensible value for psychology, though introspection remain the principal method. (3) The subconscious is further a vast field, constituting an important part of the subject-matter. (4) The methods

of analysis, possesses serious limitations. The properties of the 'Wholes' of experience and behaviour must be investigated prior to the approach of analysis and the attempt be build up a whole from parts. (5) That purpose of determination by motives (conscious and sub-conscious) is the more fundamental law of man's activities. (6) In the end, we would observe that for the most part our approach to the subject in contemporary Psychology has been prepossessed by a fascination now for one science now for another. But I believe that if we cognise the complexity of our phenomena we shall look forward to the discovery of fresh fields for investigation and new aspects and approaches.

6. Dr. B. Kuppusawmy, Mysore.

The contemporary schools of Psychology draw up different pictures of mind because the founders of the schools have their philosophic predelictions. The philosophic outlook of the originator influences the type of picture he draws up of the mind. System building is essentially philosophic. It is not scientific. There are indications that in the recent years Psychology is 'coming of age'. The work of Boring and others points to the development of the essentially scientific spirit which lays emphasis on the eagerness to find new facts and develop new hypotheses to account for them, instead of attempting to start searching for facts which fit in with certain pre-conceived philosophic notions. The picture of mind will vary in outline as well as in detail depending upon the experimental data gathered by the psychologist. Hence it is a continuously changing picture.

7. Dr. B. L. Atreya, Benares.

The main features of Contemporary Psychology and the consequent differences of opinion have given rise to a number of schools. The most prominent schools of contemporary psychology are: Structuralism, Functionalism, Behaviorism, Configurationism, Personalism, Purposivism and Psycho-analysis. A picture of man is revealed in contemporary psychology on the whole. Recent experiments in Extra-sensory Perception and Telepathy carried on by Rhine, Tyrrell, Carington and Soal and the addition they tend to make to our knowledge about human knowledge. Urgent need of a new branch of Psychology or a new school of psychologists who should scientifically study the data which has been brought to prominence by the Society for Psychical Research. These data, if experimentally verified and collected in accordance with scientific method of observation, will be a great asset to a complete understanding. As long as Psychology does not answer these questions, it is bound to remain more or less unpopular.

8. Mr. P. S. Naidu, Allahabad.

When the contemporary revolt against the strictly useless psychology of the last century took place, there was a tendency to throw *mind* and mental processes completely overboard. This reaction, however, was checked and the hormic psychologist, and the psycho-analyst have stepped in to stem the behaviouristic tide which threatened to engulf mind and mental processes.

In the study of mental life, hormic psychology adopts a synthetic attitude. It does not, however, probe down to the 'Unconscious' depths, nor does it accept purely mechanistic and deterministic explanations.

Hormic psychology adopts an evolutionary attitude towards the study of mental life. It has shown how the conative basis of these fundamental dispositions is by far the most important, and how the cognitive aspect is only secondary. The purposive nature of these dispositions is also stressed. These propensities and dispositions evolve, with the growth of the living human organism, into sentiments. Mental life, i.e., mental structure and function, first differentiate and then get integrated into patterns of varying degrees of complexity. The highest stage of mental life is reached when these sentiments are organised into a highly unified pattern of personality, with a powerful master sentiment conferring dynamic unity on the whole pattern. Purposive striving is the very heart and soul of mental life and dynamic conative unity is the fruit of this striving. All other aspects of mental life, particularly the conative aspects, are made to revolve round this central hub of Hormic striving.

This picture is further strengthened and supported by an analysis of abnormal mental life. Conflict between sentiments, the inability of the patient to resolve the conflict in normal way, the repression of a strong sentiment resulting in insanity—these are all fitted into the general picture of mental life. This picture, then, is clear in outline, complete in detail, and harmonious in regard to the organisation of its various parts.

9. DR. P. T. RAJU, Andhra University.

(1) Limiting the scope of the subject to Hormic Psychology.
(2) A brief scheme of the system of Hormic Psychology.
(3) Examination of the scheme. Biology and Psychology. Continuity of Matter. Life and Mind. Purpose and Intelligence. Instinct and Intelligence. The constant and variable in all behavior. The variable and the factors of *g* and *w* Are Emotions distinct and separate? Instinct, Intelligence and Sentiment. Application of Hormic Psychology to Ethics, Culture and Civilization. The dominance of Intelligence over Instinct or Cognition over Conation. Relation of Intelligence to Conation. How to avoid Intellectualism. Intelligence the special characteristic of Mind. Need for a determinism in explanation. The determinism of Mind.

10. DR. S. C. MITRA, Calcutta.

Dr. Sengupta has given a brief historical outline of mental life as has been conceived, e.g., to be comparable to a plane surface with sub-divisions on it marking off the different functions.

That models and pictorial representations aid us when dealing with abstract conceptions will readily be agreed to by many. It seems to me, however, that diagrams can never adequately represent mental function. Pictures are necessarily static but functions are essentially dynamic. A mechanical model therefore which may be set going by means of suitable contrivances may be more helpful than a mere diagram when we are dealing with the operations of the mind. It may be possible with such a model to demonstrate for example, what may happen should any part of it go wrong. The aberrations of the mind may have a chance of demonstration in such a model. Dr. Sengupta has not given any reference in his article to the diagram of the mind that has been drawn by Freud while trying to point out the relations between the Id, the Ego, the Super-Ego, etc.

What I would contend, however, is this. We need not at this stage in the development of our science exhaust our energies in trying to formulate critera for testing pictorial representations. Mathematics has taken the place of pictures now and it it certainly true that mathematical symbols and functions are better suited to illustrate the states and processes of mind. One obvious objection to bringing in mathematics, is of course that in introducing mathematical concepts we simply replace one system of abstraction for another. I readily agree that it may be difficult for one to understand the intricacies of mathematical formulations as to grasp the subtle workings of the human mind. But one who is determined to unravel the complexities of mind must have his intellectual powers sufficiently developed and for such an one the transition to mathematics, though it may be a difficult process, should not be an altogether impossible achievement. Attempts to symbolise mental functions in terms of mathematics is a feature, one of the most important features, I may say, of contemporary psychology and as such one should not fail to take notice of it.

I am fully conscious of the dangers to Psychology that may creep in surreptitiously when one becomes too much preoccupied with the mathematical aspects of the presentation. The chances of appearance of a variety of error are a little greater in our case it may be admitted, because of the abstract nature of the materials that are dealt with both in mathematics as also in psychology. Provided precautions are taken however to safeguard against this confusion, mathematical formulations, it seems to me, would be able to render us greater help in illustrating psychological functions than pictorial representations.

XIV. ACHIEVEMENT TESTS AND ACCOMPLISHMENT QUOTIENTS AND THEIR EDUCATIONAL VALUES.

(Section of Psychology and Educational Science.)

MR. JOHN SERGENT, New Delhi, presided.

RAI BAHADUR J. M. SEN, Krishnagar.

Achievement Tests aim at measuring what the pupil gains from school training. The Accomplishment Quotient (A. Q.) roughly indicates the progress of a pupil in his school work. The educational quotient being dependent on the school opportunity of the pupil changes in the same individual at different times. The A. Q. is a ratio between E. Q. and I. Q. and as such obviates the knowledge of chronological age of an individual. It is worth while to consider some of the

major assumptions regarding the validity of Achievement Tests and these are as follows :—

(1) It is generally assumed that a single test is a valid test of a school subject and therefore it tends to measure the student's attainment in all the important phases of the subject. A school subject usually involves a variety of the objectives and a single test in order to measure such a complex of outcomes must include exercises which adequately test the student's attainment of these various objectives. It is also desirable to give due weight to the various aspects of a subject though there is no standardized method of doing so. Under these limitations it is necessary to devise tests to measure the student's attainment of particular objectives and/ or combinations of them. Such a procedure will no doubt help the evaluations of particular objectives from different view points.

(2) The second assumption is with regard to the existence of a satisfactory criterion of validity which frequently is the correlation of the test results with the marks given to the pupils. This should not to be the case, because the object of Achievement tests is to provide the teacher with a more accurate instrument for ascertaining the students achievement. In place of this the essential assumption should be that the student's reaction in a sampling of the situations representative of the objectives is an adequate index of his characteristic reaction in all situations and that the criterion of validity should accordingly be changed.

(3) The tests which do not directly evaluate the students reactions in representative situations are nevertheless considered satisfactory indices of these reactions.

(4) It is commonly assumed that the method adopted for marking a given test will give a satisfactory evaluation of the student's responses in the light of the objective being measured, but in practice this is rarely tested. Here the best procedure would be the composite evaluations of an infinitely large number of trained judges.

(5) It is assumed that the particular numerical values assigned to test responses provide a satisfactory scale for measuring the degree to which the students have attained the objectives. The problems underlying this assumption have not been fully investigated and there is no uniformity in the procedure adopted.

(6) The reliability of the test is that it provides an adequate and representative sample of the student's reactions to all the situations in which the desired objective may be expressed. The two factors affecting the reliability of a given test are (*a*) the range of situations in which the objective may be expressed, and (*b*) the variation in the reaction of the student to a given situation. The reliability is primarily a question of sampling and may be tackled with the existing statistical methods.

(7) It is assumed that the test scores provide measurements fine enough to detect the student's progress. This is a very big assumption and the facts prove to the contrary.

(8) Any difference in test scores which is statistically significant is correspondingly of social value and desirable to have but this is an assumption yet to be tested.

2. Mr. H. P. Maiti, Calcutta.

The achievement tests are constructed on certain scientific principles and hence it has been suggested they should replace the traditional type of examinations. But what is actually measured by the tests is not exactly what is intended to be measured by the latter. The tests usually measure elements of knowledge and skill into which a particular subject of instruction or a course can be analysed and not the ability to apply the same in concrete forms.

Though the achievement tests are constructed on the same general principles as the Intelligent tests, there must be important difference between the two in so far as they measure essentially different things. This would practically mean that there are a number of special problems in connection with the technique of achievement testing that should engage the special attention of the research worker.

The greatest merit of the achievement tests lies in its objectivity and ease of scoring. The average reliability of most of the existing achievement tests ranges between from ·60 to ·98. But it is about the validity of the tests that we have at present reasons to be least satisfied. We must evolve through experimental work a better criterion of validity of the tests.

As they are, most of the achievement tests cannot be said to give an exact and reliable picture of what a pupil has learnt at a particular stage of his education, and hence they cannot be regarded as good substitutes for examinations, in spite of the obvious defects of the latter.

Though achievement tests have certain obvious limitations and defects, they have undoubtedly distinct educational values. They constitute valuable supplementary method of measurement of a pupil's school attainments. When achieve-

ment tests results are expressed in relation to a pupil's intelligence, we have A. Q. with a distinctive significance of its own. A. Q. helps us in the diagnosis of school failures and in guidance of school work. But it is difficult to understand how in calculating it, one can altogether obviate the need of considering the chronological age of the pupils. Even if this were theoretically possible—though it is not—much of its practical usefulness would be lost.

3. Dr. (Miss) K. H. Cama, Bombay.

In India generally examinations are held under the teachers who usually teach their pupils. It is possible that the teachers can properly estimate their pupils' real shortcomings, aptitudes, etc., but at the same time it may be possible that teachers can be biased in one way or the other. So it is always desirable that the examinations should be done under other educationists who may be termed as visiting teachers.

But as the examinations in their methods, forms, etc., are different in different schools so it is desirable to have standardised test which can be applied to all schools and standardised comparative results can be obtained. In this way the tests can be performed to the best of the pupils' ability if the examinations are done by visiting teachers who may also be able to judge better the different school's progress than the teachers of the same school.

4. Mr. S. Mathai, Delhi.

It has been found that the results of the so-called tests do not tally with the class-examination results. It is doubtful whether these tests are absolutely reliable or not as doubts are always expressed by many a one if the tests really measure the intelligence. If the tests themselves are not reliable then the values of I. Q. or A. Q. vitiate from reality. So efforts should be made first to have a reliable test to measure both I. Q. or A. Q.

5. Mr. H. P. Mehta, Karachi.

It is very difficult to get the real values of I. Q. or A. Q. Great many factors play their parts at the stage of examinations as well as at getting their values. There are varieties of disturbances which may work has hindrance in getting the real values. If a student is mentally disturbed when the tests are applied to him or if a student copy from another or likewise, leaving aside so many chance factors that play important parts in getting the test value, are all distracting factors which are most likely to hamper the real value of I. Q. and A. Q. Means should be found out to eliminate these distracting factors and to get the real values of I. Q. and A. Q.

6. Dr. Rabi Ghosh, Calcutta.

Accurate aging of the testees is almost impossible in the application of Intelligence Tests in India. The concept of I. Q. is based on precise determination of the chronological age, but the concept of A. Q. does not involve that difficulty. Accomplisment Test-results can have therefore more practical value and accessibility to practical interpretation.

Accomplishment Tests on the one hand registers a practical measure of the amount of intelligence available for purposes of education in the school. They also indicate in a measurable way all those other factors which are called into operation in the performance of the specific tasks of the school in that setting.

For obvious reasons A. T. results of the students create interest for their teachers as much as they would be interested to know the results of the usual formal examinations in schools. At the same time such notifications of success may nip in the bud the extra emotional investment of the respective positions in the result sheet. This investment do not always bring practical return as has been observed. On the contrary, it leads to blind alleys as becomes evident when the question of career-choice comes up. Achievement Tests to be used for measuring the success in schools will therefore lead to rational outlook.

A. Q.s will help authorities to subdivide students in a class for practical administration into separate sections according to the abilities of progress. A. Q.s at different ages of the same pupil and of different students in the same class will be more enlightening and convey more reliable data to the student, his teacher and guardian. Educational difficulties will be indicated, educational expectations will be predicted and the amount of normality will be forecasted. They convey more information than the I. Q.s for the purposes of vocational guidance.

7. Mr. Pars Ram, Lahore.

1. Achievement Tests are an improvement upon the methods of testing a pupil's proficiency in vogue at present. These tests use a large number of short questions which exhaustively explore all branches of the subject. This is in sharp contrast with the traditional method of examination which consists in giving a few questions demanding long answers. The new tests, therefore, offer a wide range of opportunities to the testee to display his mastery of the subject and they leave nothing to chance. Achievement tests also eliminate the handicap that slow writers usually experience as these tests demand the minimum of written work. Since achievement tests are selected after a good deal of trial and experimentation, they are more or less objective.

2. The use of standardized achievement tests is likely to influence educational practice in the following ways :—

(*a*) In due course of time the use of achievement tests will result in more reliance on the teacher's opinion and the child's record and thus dispense with the necessity of the centralized examination system.

(*b*) These tests have a diagnostic value and are likely to be of great value in a homogeneous classification of pupils on the basis of the type of ability they have in a particular subject.

(*c*) The process of preparing achievement tests is very educative to the teacher as it helps him to experience for himself, the various grades of difficulty and complexity of the subject and the type of mental abilities required to master the subject.

3. It is urged that training colleges should undertake to instruct teachers under training in the art of preparing achievement tests.

I. THE PLACE OF SCIENCE IN THE INDIAN EDUCATIONAL SYSTEM.

(Authoritative summaries of the speeches sent by the participants as they have been available are published below. Names of those who had taken part in the discussions but did not sent summarries of their speeches have not been noted.)

1. A. N. Basu, Calcutta, opened the discussions.

We are in the midst of a world war. As the war prolongs with all its horrors and sufferings it is becoming more and more evident that our social structure needs remodelling and reconstruction on entirely new lines. Indeed the calamitious war that has engulfed the whole world is but the three of the birth of a new world order. It has become a recognised fact that any post-war reconstruction, social or otherwise, must harness science to the service of humanity, if it is to foster democratic conditions and herald a new era of peace and prosperity. In enlisting the services of science for the establishment of the new order we shall have to wage a relentless war against two fronts. We shall have to fight against ignorance and complacent beliefs on one side and against exploitation and the use of the applications of science for anti-social purposes on the other. The attitude and habits of imagination coming from a satisfaction with beliefs and assumptions having no basis in factual observations constitute our enemy number one while utilisation of the applications of science in group interest to the detriment of the welfare of the masses is our enemy number two.

Wonderful as has been the achievement of science, it has so long been, as a result of its having outstripped social progress, the handmaiden of war and competitive industry. If science is to be rescued from his ignominous role and made to contribute towards the creation of a juster order of society that will humanise the industries and will transform the bewildering complexity of a ruthlessly competitive world into unity and plan, it is necessary that we should re-educate the people and bring about a generation of new men and women imbued with the spirit commensurate with the great task that lies ahead of us. In planning for the re-education we shall have to ask and answer a good many questions and one of the most important of these is—will future education permit science to enslave us or will it so illuminate life, so fill it with high enthusiasm that science will be made into a ready servant of man's aspirations?

The purpose of my addressing you today is not to make out a case for the inclusion of science in the primary and secondary school curriculum. You are all aware of the pleas that are generally advanced in text-book on educational practice to stress the importance of the study of science not only in the high school but also in the primary and infant school stages. It is rather late in the day to discuss the cultural and disciplinarian values of science, its utilitarian and avocational aspects. However grudgingly it may be, science has already been

given a place in the curricula of our universities and schools. The question to-day is not whether we should teach science but what science to teach and how to teach it. The encyclopaedic Comenius wanted the child in a child's way to begin all the sciences and that is not far from what the science curriculum of schools today want him to do in acquiring useful information. The scrappy and trivial value of some of the science which is taught reflects the encyclopedic character and the chaotic arrangement of our school curriculum in elementary science.

This brings us to the question of educational objectives. Of all the ills that beset the educational system in vogue in our country today the one that seems to have successfully eluded the notice of those hitherto entrusted with the task of educational planning, is that our schools lead to nowhere. The considerations that influenced them in determining the educational policy were more a matter of administrative expediency than that of adjusting education to the social needs and the economic interests of the people concerned. But this is largely a question of history and I do not propose within the short time I have at my disposal, to go into the historical conditions which led to the inauguration of the present educational policy. What I should like to impress on you is that if our children ought to get that vital science experience which alone can equip them to battle with the exigencies of a changing world we must first make sure of our educational objectives and relate them to our imperative social and economic needs.

I am sure we shall all agree that the general aim of all education is desirable behaviour. The Educational Policies Commission of the National Education Association of the United States further analyses and elaborates this concept regarding the general aim in the following terms:—

1. Education for self-realisation involves command of important physical and intellectual skills, knowledge and practice of healthful living, ability to play, love of beauty and growth in self-direction.

2. Education in human relationships includes laying the basis of a satisfying home life and pleasant and useful associations with others.

3. Education for economic efficiency involves preparation of competent producers and consumers who understand economic forces and can constructively help to solve their own problems.

4. Education for civic responsibility includes increasing the social, economic and political understanding of individuals, and increasing their ability and desire to improve their corporate life.

These aims, it will appear, emphasise the abilities, understandings, attitudes and appreciations that children should have as workers, parents and citizens; and a science curriculum built on the broad basis of these educational aims should stress those abilities, understandings, attitudes and appreciations through appropriate kinds of action or behaviour. I need not remind you of the unrelated bits of information and the inane generalisations that are taught as science in our schools. We teach our children rudiments of biology and yet they remain unconcerned about the myriads of life-forms which swarm around them. We teach them the elements of geology and extend their vocabulary with the sonorous names of rocks and geological ages and yet they cannot distinguish a sandstone from a granite or trace their influence in the soil which covers their kitchen garden. We give them a touch of the romance of astronomy but still they cannot find the true north at night or tell time by the moon. They absorb an amazing assortment of scientific information; but that does not preclude them from transgressing the simple rules of personal hygiene or such social regulations as are based on applications of science. One of our big problems in the field of public health has been the unscientific as well as anti-social attitude even of men who have had studied all about science and its applications in their schools and colleges and yet who would not apply their knowledge to the solution of their every day problems. I am sure you are all familiar with such people. They will glibly recite the generalisations of science and will wax eloquent in their defence but cannot see the incongruity of turning to magical formula and rituals for relief in their afflictions. Of what use has science been to those who have been taught it? The odd bits of scientific information they have gathered have been what Whitehead has called "dead and inert masses of knowledge"; they do not influence their life and conduct; rather they act as a drag.

In deciding what science we must teach, our only determining criterion should therefore be to ascertain what educational purposes it will serve; and in indicating how it shall be taught we must evolve such instructional practices as will induce children to translate their contacts with science into appropriate actions or behaviour. If science has anything to contribute to the enrichment of our individual and social life its study in the school grades should in the first place emphasise the development of a scientific outlook on life, an outlook which is

at once scientific as well as social. For, we must remember that a truly scientific attitude is never anti-social nor even a-social. Secondly, as the study of science is to be related to life and it is to lead to socially desirable behaviour such study should emphasise the direct application of science for the improvement of human life not only in its material aspects but also its social relationships. It should unfold to the young scientist practical reasons for the social co-operation which he hears about so often. He should realise how many of the afflictions he and his neighbours suffer from are man-made. It is not difficult even for children to understand how wanton deforestation in the upper catchment of the Damodar basin has been the precurser of devastating floods; how the thoughtless killing of the iguana in North Bengal has led to the multiplication of such garden pests as the land snails; how the community might become an unenviable place if it did not unite in a scientific fight against flies, mosquitoes and other pests and enforce sanitary standards. The state enforces sanitary rules, forest reservations and quarantine regulations. All these social regulations are the results of applied science. The science curriculum if it is to contribute materially to the realisation of the educational purposes should include such applications of science as have given us utilities that serve the community.

Secondly, the science that our schools teach not being closely related to the child's environment has an air of unreality about it. Many of our budding scientists will readily account for the rosette leaves of the unfamiliar daisy but at the same time fail to point out the advantage of the tall outstanding flowers to the familiar plantation. Until the science our schools teach seeks to interpret to the child his own environment it cannot affect his behaviour.

Thirdly, science instruction is even at its best carried out through formal lessons given at set periods. It has ignored the psychological fact that child's mental images, concepts and power of imagination grow out of what he sees, handles and does, and words, even when supported by visual aids, mean little to him unless associated with active experience. The science master's functions is not to teach science but to bring his pupils into contact with the right kinds of science experience.

It would thus appear that the new aim of science teaching will not call for so much of factual instructions or of scientific classification as of developing a sharpened insight and of fostering interests in matters that contribute to the common-weal of the society. The new science we shall teach should bring about contacts with things, living organisms and movements of life. It will provide our children with opportunities to use their eyes, hands and independent brains. It will, in short, seek to build up the kind of mental integrity that grows out of direct contact with the realities of life. This science will have a community individuality and will stress its practical and social applications.

The training programme for teachers of this new science should not only give them an adequate knowledge of the basis scientific generalisations but should also provide them with opportunities for such first-hand observations as form the basis of these generalisations. It should bring home to them that even elementary science can be connected with practical pursuits and that many problems in it can be introduced by directing pupils' attention to local conditions. It should besides make them conscious of the inadequacies in the industrial, economic and public health organisations of their own community and develop in them the right kind of social consciousness.

The teaching of this new science will be in the hands of a teacher who must not only have an adequate knowledge of science but will also be keenly aware of its potentialities in promoting the common weal. His academic and professional training should not be confined to science, still less to one branch of science for he must not offer to children a course solely based on his own academic and professional studies in sciences but should constantly bear in mind the relation of science to other parts of the curriculum as well as to the social and economic interests of the community it is his privilege to serve.

Schools teaching this new science will have to be adequately equipped. In speaking about equipments I am not thinking about gas burners, electric points and such neat apparatus and scintilating glasswares as can be bought from commercial scientific concerns. Most of the specimens required can be collected by the pupils themselves. A good number of the apparatus needed can be made locally under the direction of the teacher. But even this will cost money and that money has to be provided for. Then there has to be a nature garden, an aquarium and cages for animals, birds and insects. A museum service will have to be set up for providing visual instruction and the lending of costly models and specimens to a group of schools. If all this is worth doing money has to be found. Mr. John Sargeant by his courageous planning for post-war educational reconstruction has given us a very useful lead in this direction.

To sum up then, I suggest that:

(1) a new orientation is to be given to science teaching; this should be in consonance with our general educational objectives. We must define these objectives clearly as we must define our aims of science teaching.

(2) The entire science curriculum is to be recast and reoriented in the light of our aims. It is to be correlated with other subjects in the curriculum and also with the life experiences of the pupils. Such correlation is specially necessary between science, hygiene and civic training.

(3) The technique of instruction is to be reorganised on the new basis suggested above.

Further, I would suggest that in each province a commission should at once be appointed to go into the question and to give concrete directions. The Commission should consist of teachers and scientists as well as administrators.

I have no pretension to scientific training but as a teacher I have felt and I feel confident that many of you share this feeling with me, that science freed from its bondage to medieaval war-lords and industrial magnates will materially contribute to the creation of a new world order and that our science instruction should be planned on the basis of the new role that science has to play. It is for you to indicate the pattern of the new science teaching and say that if education builds on this pattern it will assuredly become a powerful directive force in the building of a far more adequate civilisation than we have today.

Dr. K. C. K. E. Raja.

The two previous speakers dealt with the subject from the point of view of the cultural aspect and vocational training respectively. I should like to invite attention to a third and equally important aspect of the problem, namely, that of extending as far as possible the field of selection for research workers.

Even in countries where research has been encouraged much more than in India, the field for the selection of the scientific worker has been limited. The opportunities for training in special branches of research are not open to all. Conditions such as birth, social position and wealth continue to influence to a large extent the scientific careers that are open to individuals. Even with the introduction of universal education up to the elementary and secondary school stage and the provision of facilities for further training through State aid of deserving pupils, the net has not been cast sufficiently wide to ensure that those who are gifted by nature for a career of scientific research are secured for the service of the country. It is only by introducing training in science in the early stages of education and by promoting the scientific outlook that the child with an aptitude for research can be discovered and encouraged in later life to contribute his share to the advancement of scientific knowledge.

We must get away from the idea that research for the furtherance of knowledge is the privilege of the few. Scientific research is based on the development of a talent for making careful observations, of recording them correctly and of drawing suitable conclusions from them. Two instances may be quoted. They are from the field of public health with which I am more familar than with other subjects. About 180 years ago an English physician named Sir George Baker was consulted about some cases of colic and arm paralysis in Devonshire. He went down to the place and on investigation found that a large number of patients had been admitted to the hospital at Exeter with the same malady and that there was an association between this outbreak of diseases and the drinking of cider. Further enquiries showed that about eight times as many patients came from Devonshire as from cider-making localities in the neighbouring counties of Hereford, Gloucester and Worcester. On further investigation he found that the cause was the presence of lead in the cider which the people drank, it having been introduced during the process of manufacture, either through cider presses clamped together with iron fixed by melted lead, or in certain cases from the casks or vats containing leaden weights which had been put in to prevent the cider turning sour. Chemical analysis proved that the Devonshire cider contained lead in solution, while the Hereforeshire cider did not. Here is an example of the application of scientific method in the investigation of a problem requiring only powers of observation and of inductive logic.

Another instance is the discovery of the protection that cowpox can confer against smallpox by Edward Jenner towards the close of the 18th century. His starting point was a tradition which was prevalent in Gloucestershire that persons, who developed from the cow an infection which had a rescemblance to smallpox, were thereby rendered immune against smallpox. To verify this hypothesis Jenner inoculated a small number of persons with the material from cowpox and, after a time, with material from smallpox and in every case the persons concerned did

not develop the disease. In view of the known fact that natural immunity to smallpox exists in a certain number of persons, the evidence produced by Jenner might not be considered sufficient to justify the conclusion that he drew. Nevertheless, his hypothesis was proved, many decades later, to be quite correct by experimental evidence being produced to show that the smallpox virus can by passages through the calf be converted into the cowpox virus. Such work has been done in England, in the U. S. A. and a few years ago at the King Institute, Guindy.

I plead for changing the mode of teaching science in schools. It is essential to change the present system of teaching science. What is required is to give the growing child an idea of the dramatic character of scientific advance as well as to arouse his active interest by enabling him to translate what he is taught into practical action in the daily affairs of life. The history of science can be taught in such a manner as to stimulate the child's curiosity and to correct any tendency towards dogmatism by pointing out to him how the application of the results of scientific research has resulted in the betterment of living conditions and how, at the same time, the theories on which scientific advance has been based are subject to continual change.

The practical application of the theoretical knowledge that is given to him is all important. For instance, in the field of health education, it is not sufficient to inculcate the principles of healthful living by a series of talks to the child. The necessary facilities should be provided and the child should be taught, during his school hours, to use these facilities in order that healthy habits may be developed. In America I understand that instruction in nutrition is reinforced by the children being divided into groups and each group being given a certain number of rats which they are to feed with special diets. The children make observations from day to day and record them. The result is that they acquire a more intimate knowledge of the effects of ill-balanced and well-balanced diets on health than they can derive merely from books or from lectures. Further, the habit of making observations and of drawing inferences from them will prove valuable to them in whatever walk of life they may be engaged in later years.

Further, when science is taught in schools with a bias towards its application to life of the community, the intellectual and emotional development of the child should be on correct lines and should help to equip him for his future responsibilities as a citizen.

Mr. Bose has suggested that provincial authorities should set up committees for drawing up a programme in order to give science its rightful place in the school curriculum. I submit that, for the sake of securing a reasonable measure of uniformity, a central committee should undertake this task and that its programme should be made available to provincial authorities for such alterations as they may consider necessary to suit local requirements.

REPORT OF THE DELHI SYMPOSIUM

The symposium on Science and Its Place in Indian Education was held in the Delhi University Hall at 3 P.M. on the 3rd January, 1944, with Mr. John Sargent, the Educational Adviser to the Government of India in the Chair. There was a large attendance of delegates and visitors.

Mr. Sargent explained the objects of the symposium in a few words and then called upon Mr. A. N. Basu to open it. In his speech Mr. Basu defined the aims and objectives of teaching science with special reference to this country and examined the present position of science teaching in the light of these aims. He suggested that science syllabus should be revised and the teaching methods improved and in order to give effect to these suggestions he recommended that the provincial governments should immediately appoint expert Committee to go into the question.

Mr. Basu was followed by Dr. W. W. Wood, the Principal of the Delhi Polytechnic who emphasized on correct methods of developing scientific outlook in our pupils through hobby clubs and other such devices. Then Rao Bahadur Dr. K. C. K. E. Raja addressed the symposium. He discussed the problem from the public health point of view.

The discussion was then made open to the members of the audience. Mr. Sargent called upon Prof. A. V. Hill to speak a few words on the subject.

Prof. Hill began by observing that the attitude of educational administrators was not always in favour of science. He quoted the example of the Headmaster of the Harrow School who spoke disparagingly of the arrangements for teaching Biology to the sixth form boys. We have to realise, he said, that there was no conflict between the old classical culture and the new culture based on science.

It is a pity that men were not educated enough to appreciate the value of science. Prof. Hill pointed out that all of us need not learn all about everything in science but that we should be familiar with certain principles and their application. Such knowledge will help us to develop the correct scientific outlook.

Mr. Altaf Hossain of Hyderabad then referred to what was being done in the Osmania University in the matter of teaching science. General science both theoretical and practical had been made compulsory there.

Dr. J. F. Bulsara said among other things that the development of the correct scientific outlook was more important than mere teaching of scientific facts.

Dr. V. S. Pao pointed out that it was not possible to improve science teaching without first improving the lot of teachers of science.

Dr. M. N. Saha emphasised the necessity of educating the people into a correct appreciation of the values and contributions of science to modern life. He told a story of how on one occasion administrators who lacked such education were on the point of destroying important scientific work that was being carried on in a well-known scientific institute in this country.

The symposium was concluded with a few remarks from the Chair.

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INDEX

A

B

C

D

E

F

G

L

M

N

O

P

Q

R

T

U

V

W

Y